ROSSINI: RobOt kidS deSIgn thiNkIng

Simon Haller-Seeber[1], Erwan Renaudo[1], Philipp Zech[1], Florian Westreicher[2], Markus Walzthöni[1], Stefan Strappler[3], Cornelia Vidovic[1], and Justus Piater[1]

[1] Department of Computer Science, University of Innsbruck Technikerstr. 21a, 6020 Innsbruck, Austria
[2] Youth University, University of Innsbruck, Innrain 52, 6020 Innsbruck, Austria
[3] FabLab – Spielraum für alle, Franz-Fischer-Straße 12, 6020 Innsbruck, Austria

Abstract. ROSSINI is a DiY educational robotics project launched in Tyrol in 2017. ROSSINI aims at providing a platform for children and youngsters to gain their first experiences with robotics and related technologies, viz., mechanical and electrical, as well as software engineering, embedded in the context of both design thinking and upcycling.

Keywords: educational robotics, design thinking, do it yourself

1 Introduction

In an effort to address industry's growing need for qualified personnel in STEM-related professions, recent years showed an emerging trend of, broadly speaking, educational *digitalization* workshops and tools. After hosting the RoboCup Junior Austrian Open in 2016 we saw that there were not many such workshops in Tyrol. Most of the educational robotics initiatives took place in eastern and southern Austria; only some Lego Mindstorm robotics courses were offered in Innsbruck. Seeing the need to bring educational robotics not only to schools but also to children directly, we launched ROSSINI in 2017.

Before starting the ROSSINI initiative, we surveyed other existing initiatives and robotic kits (e.g. [7,6,9]), attended a workshop on educational robotics[4] organized by the Austrian Computer Society (OCG), and talked to several teachers and coaches at the RoboCup Junior Austrian Open to obtain a broad overview on different educational robotics initiatives in and around Austria. Having these initiatives in mind we decided that ROSSINI participants, apart from getting in touch with robotics, should not only improve the skills of 4C (collaboration, communication, critical thinking, and creativity) but also learn problem-solving strategies, and additionally the course/workshop should raise their curiosity. The ROSSINI initiative targets children aged seven to twelve and, importantly, also children whose parents cannot afford expensive robotic kits.

All the workshops are built around five core concepts (see Section 2) to bring robotics to children, enhance their collaboration, communication as well as their

[4] OCG Educational Robotics (ER) work group: https://www.ocg.at/de/educational-robotics

problem-solving skills, and children experience all or part of them depending on the workshop duration:

- Design Thinking
- Computational Thinking
- Upcycling and Waste management
- Free Software and Open Hardware
- DiY Rapid Prototyping

Finally, to give the children the ability to pursue by themselves their exploration of robotics and technology, we aimed at making both the workshop and its material easily accessible. Whereas many educational platforms exist and are used at various educational levels ([11]; among which e-puck [9], Thymio [12,6], Lego Mindstorms [1], etc.), their price is usually too expensive for modest families. We thus focused on a custom platform that possesses most of the necessary sensors and actuators to express interesting behaviors but can nevertheless be provided to families at a low cost (see Fig. 2). For ROSSINI workshops, the robot value amounts to 30 EUR and for ROSSINA to 65 EUR, whereas other available platforms start around 100 EUR (excluding any workshop registration cost). We also made the workshop fee affordable for a wide range of families: registering for one workshop day cost 5 EUR. At the end of a workshop, the families could choose to buy the platform built by their children. Whether or not they keep the robot, the material to build them is available online (see Section 3).

2 Five Pillars of ROSSINI

To implement the self-imposed goals for this workshops (enhance collaboration, communication, critical thinking, creativity and problem-solving skills of participants) while maintaining an environment-friendly course we decided to create the workshop on these 5 pillars:

Design Thinking

Design thinking is generally defined as an analytic and creative process that engages a person in opportunities to experiment, create and prototype models, gather feedback, and redesign. Design Thinking is used because it encourages innovative thinking and finding creative problem solving strategies. It also results in experiences that are effective and informative for learners [10].

Computational Thinking

Computational Thinking guides youngsters to express real-world problems in computational terms. This includes the concepts of loops, updating sensor measurements, and how to compute suitable output values for either a decision process or a controllable device on microcontrollers. To avoid confusion and overexertion it is important to impart this way of thinking in a fashion that makes it easily accessible and suitable for children. The goal is to keep the design as simple as possible for the desired task to learn.

Upcycling and Waste Management

Just like recycling, upcycling is a way of reusing waste. In a particularly creative way, worthless material is transformed into something new and valuable. Important issues for our workshops about upcycling and recycling are that it is relatively easy to do, it reduces waste, and children learn how to make great new things for their robots. It also enables creativity in finding solutions for their prototyping.

Free Software and Open Hardware

There are many good and important arguments for using Free Software (exclusively). We conjecture that schools have a social mission to promote this strongly; unfortunately this is very much neglected in Austria's educational institutions and (for various reasons) strongly neglected in Austria's school system (see e.g. [4, p. 4]). We made this one of the pillars of ROSSINI, most importantly for the following reasons:

Cooperation: By using free software, children learn to share and cooperate.

Independence: The possibility and freedom to create and try things motivates children to learn more (e.g. programming)

Easy to manage: Free software is stable, secure and reliable. It offers unlimited access to the source code – the software can therefore be adapted to the individual needs and, even more importantly, it also allows you to see how it works.

Flexible: Free licensing of software means that the programs can be adapted and modified.

Sources of supply: Due to the license terms of Free Software it is possible for any person or institution to offer a software on the one hand and to download and use it on the other hand.

With free software we can give copies to all participants without having to worry about legal security – because the license does not pose any danger of illegal use. We are convinced that with ROSSINI we are also giving children and young people a start towards more frequent use of Free Software.

DiY Rapid Prototyping

Teaching the workshops in a fablab has several advantages. We can directly use different prototyping technologies such as 3D printers, laser and vinyl cutters, and many different tools are at hand. Not only is it easy to prototype and construct physical objects at the fablab; we can speedily create them with many types of materials. Using block-type programming for microcontrollers we can easily demonstrate different concepts and speed up the prototyping process. Therefore the whole prototyping process can be done in a fun, do-it-yourself way.

3 Workshops

Two types of workshops were designed:

ROSSINI long workshop,
ROSSINA short workshop

They are organized such that there is a supervision rate of one teaching person per two to three groups, each group including no more than two members. As pointed out by Magnenat et al. [8], this low student-per-teacher ratio allows for higher-quality supervision than at school. Whereas ROSSINI workshops cover the five pillars described above, the ROSSINA workshop focus on a subset of them for shorter events (e.g. Girlsdays, Youth University courses). As we set *Free software and Open Hardware* as a pillar of the ROSSINI initiative, technical details, including design, software, hardware and wiring of the robots are publicly available online[5].

3.1 ROSSINI

The full ROSSINI workshop is a three (half)-day course. During this extended period of time, children experience the "design thinking" way of addressing a complex problem, namely building a functional robot. Children are assisted by experts during the process, and the activities range from attending a presentation to solving technical problems and then sharing their solutions. The focus of the workshops is not on technical problems that occur when building a robot – we rather show how to learn problem solving efficiently in a team. A typical workshop schedule is briefly described below:

Fig. 1. ROSSINI Workshop at the Fablab facilities.

[5] https://git.uibk.ac.at/informatik/rossini/resources

Understand & Observe: The children receive a short introduction to the history and fields of robotics.

Define: After groups of two children have been formed, they receive a work assignment: What should our robot look like? What should it be able to do? This is discussed and debated in the teams. Usually, enthusiasm in the groups quickly leads to a productive working atmosphere. The children exchange and discuss their ideas.

Ideas are found: Teams work collaboratively. In each group the children summarize their ideas and draw their robots and team logos. Additionally, children are encouraged to find their perfect team names. This leads to co-identifying as a team and with the robot.

Sharing: The teams show their work to each other.

Developing a prototype (hardware): Experts present a short introduction to electronics and soldering.

With wood scraps, cardboard and scrap materials (upcycling), a robot base platform is built. The children fetch materials, cut, glue, think about it, talk it over. This leads to different divisions of work within the teams.

Developing a prototype (software): After a small lecture and introduction to block-type programming small tasks are set and solved together. The children find out how to connect and program their sensors and actuators for their robots correctly.

Developing a prototype: The children improve and fix all electronic and mechanical parts where some parts might be 3D printed or laser-cut. The team logos are engraved onto a part of the robot. The children finalize the software of their robot.

Outcome: The outcome of the workshop is a working robot. Now it is time to present the achievement; additional time is given for feedback and reflection.

3.2 ROSSINA

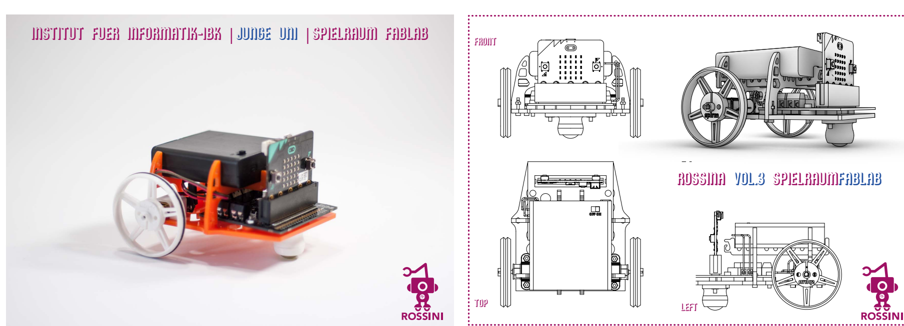

Fig. 2. ROSSINA Robot build at the fablab, designed for workshops of up to 4 hours.

ROSSINA workshops are 2 to 4h long. Due to the limited amount of time for these sessions, the children use pre-built, 2-wheeled robots and focus on the software part on the embedded BBC Micro:Bit (see Figure 2). They are given an introduction to robotics (Understand & Observe), and then have to program the robot to solve a set of tasks (Developing a prototype). They then compare their solution between teams (Sharing, Outcome).

4 Evaluation

Three ROSSINI and two robotics courses within the Youth University were evaluated in 2018. In those one- to three-day courses 48 children participated, and at the end of each course these participants filled out a questionnaire. The questionnaire was developed at the Youth University in collaboration with two sociology students for their master thesis [3]. It has been in use since 2007 and is adapted slightly to the current requirements every year. The questionnaire contains quantitative and qualitative questions and was thoroughly tested and re-evaluated in 2015. It however does not include workshop-specific questions. All other children university summer activities around Innsbruck were evaluated as well and were examined the same way. From those courses all 360 questionnaires were processed.

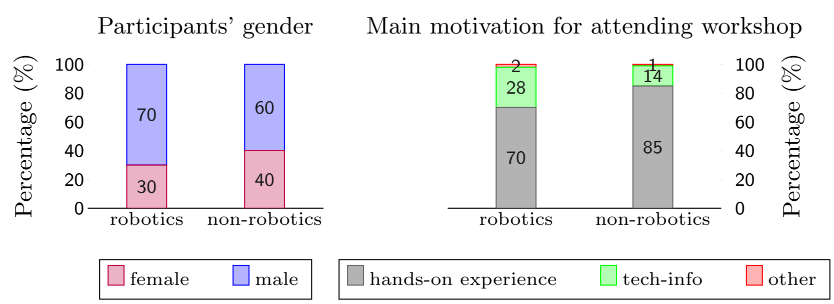

Fig. 3. Left: Participants in robotics (48 children) and non-robotics (360 children) workshops in percent. Right: Main motivation for attending a workshop.

The activities of ROSSINI represent about 14% of the children's university workshops for this period. Roughly 70 percent of the attending children were boys and only 30 percent were girls. This percentage is nevertheless higher than the about 20% that were reported in computer science studies in 2014 in the USA [13]; however, male participants are still more represented than female for non-robotic activities (see Figure 3, left).

The children were asked to evaluate the following points: (a) What kind of jobs are the parents working in? (b) What was their motivation to enroll for the robotics course or another course from the Youth University summer program 2018 in their free time? (c) What job were the children willing to do in the future? The answers were classified into academic/tech jobs and jobs in other fields using the international job classification ISCO-08 [5] and the national occupational classification system BIS [2]. Examples of academic/tech jobs as defined in the ISCO-08 standard (e.g. main groups 2 and 31,35) are science and engineering (associate) professionals. All other answers were classified as jobs in other fields. These results are compiled in Figure 4 on the left. There is a higher proportion of children from families with tech jobs attending robotic workshops than non-robotics workshop. We observe that the main motivation for children to attend a workshop is to gather hands-on experience on a specific topic (70-85%). However, due to the nature of robotics as a technical field, getting knowledge about technology is provided as a reason twice more in the case of ROSSINI workshops (28% as compared to 14%). We interpret this difference as the fact that topic-specific workshops are a good occasion for children to learn about topics not discussed at school and thus expressing their own interests. For ROSSINI participants, we can however see (Figure 5) that children are primarily motivated by hands-on experience, and this motivation is independent from their family environment.

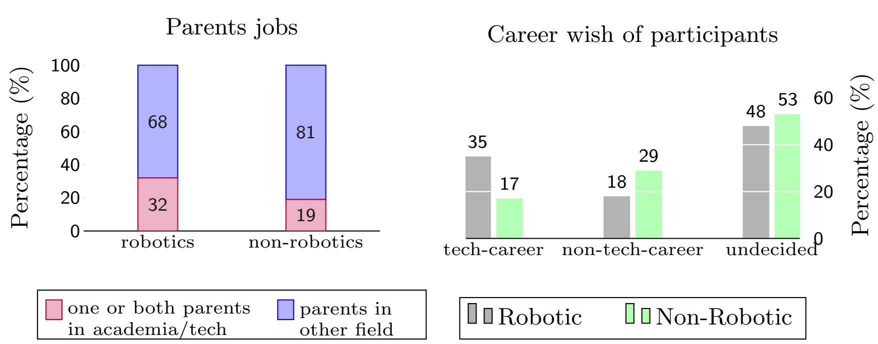

Fig. 4. Left: Coarsely-categorized jobs of parents of workshop participants. Right: Career wish of workshop participants (Grey: Participants of robotic workshops; Green: Participants of other workshops).

Figure 4 on the right shows the expressed career wish of children. For both robotics and non-robotics workshops, the percentage of undecided children is high (resp. 48% and 53%) which is a predictable result for this age group. For the other children, there is a higher interest expressed towards tech careers for participants of the robotics workshops. This is also consistent with the hypothesis that children interested in technology engage with robotics due to the recent publicity of developments in the field (e.g. Boston Dynamics videos). For ROSSINI specifically, children from a tech-related environment seem not particularly biased towards technology whereas it is the case for children without such environment (see Figure 6). This is a surprising result as we would expect the opposite bias. It is hard to provide a strong explanation without more social information on the participants. This is thus a limitation in the analysis of the workshop from a social perspective.

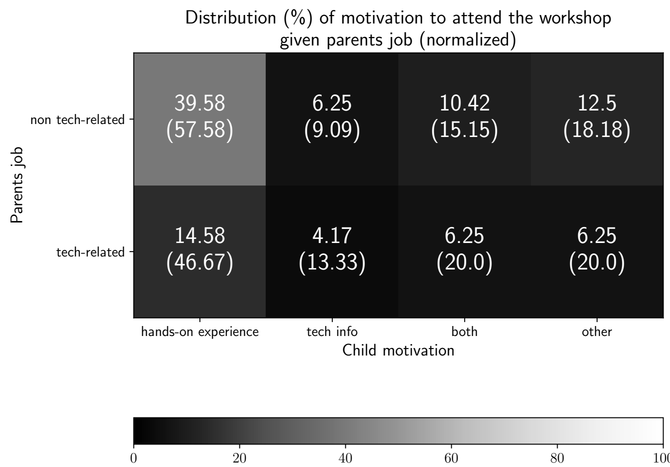

Fig. 5. Relation between the child's motivation to attend the workshop and their parents' relation with technical and academic fields. The top values represent the overall distribution of children among motivation and parents' relation with technology whereas the bottom values (in parentheses) are normalized given the parents' relation with technology.

5 Conclusion

We managed to establish age-appropriate robotics workshops for children at the age from seven to twelve. In the workshops the children start with a drawing and successively develop and build a robot with a creative spirit, which is needed when making something from upcycled materials with do-it-yourself ideas. We see that the combination of the ROSSINI pillars provide an exciting learning environment. None of the ROSSINI pillars is new by itself, but the importance of keeping and teaching those together is paramount. We think that Austrian school education would benefit from combining such strategies especially if they strengthen their effort in using free software and open hardware.

Looking at the evaluation of the ROSSINI and Youth University courses, we hardly find influence of the parents' job on the children's motivation or career aspiration. A sound explanation lies in the limitations of our study. The focus of this work is to present the initiative in an area (Tyrol/West Austria) that

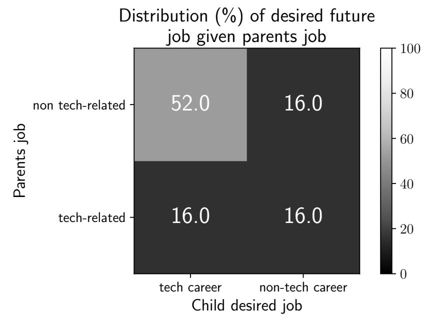

Fig. 6. Relation between the child's will to work in a tech job and their parents relation with technical and academic fields

lacks such accessible technical workshops for children. The social reproduction phenomenon has been highlighted before; ROSSINI aims at tackling this effect. A future development of the project is to provide more easily-accessible courses with digital content. This would be a suitable step in the direction of educational equality.

References

1. Akin, H.L., Çetin Meriçli, Meriçli, T.: Introduction to Autonomous Mobile Robotics Using "Lego Mindstorms" NXT . Computer Science Education **23**(4), 368–386 (2013)
2. Arbeitsmarktforschung und Berufsinformation des AMS: Berufsinformationssystem (bis). Arbeitsmarktservice Österreich (dec 2019), https://www.ams.at/bis/bis/
3. Bauer, M., Moser, C.: Evaluation der Jungen Uni Innsbruck 2007 - eine empirische Untersuchung. (2008), Diplomarbeit
4. Haller, S.: Über "Bildung 4.0", "Schule 4.0" und andere Dinge, die keine Versionierung brauchen. Medienimpulse **26** (3 2018), https://journals.univie.ac.at/index.php/mp/article/view/mi1187
5. International Labour Organisation: International standard classification of occupations (isco 08). Statistik Austria (oct 2017), https://www.data.gv.at/katalog/dataset/2bf2a6eb-69b8-39b6-917d-42fdc1dfebf3
6. Kradolfer, S., Dubois, S., Riedo, F., Mondada, F., Fassa, F.: A sociological contribution to understanding the use of robots in schools: The thymio robot. In: Beetz, M., Johnston, B., Williams, M.A. (eds.) Social Robotics. pp. 217–228. Springer International Publishing, Cham (2014)
7. Lammer, L., Lepuschitz, W., Kynigos, C., Giuliano, A., Girvan, C.: ER4STEM Educational Robotics for Science, Technology, Engineering and Mathematics, vol. 457 (10 2017), https://doi.org/10.1007/978-3-319-42975-5_9
8. Magnenat, S., Riedo, F., Bonani, M., Mondada, F.: A programming workshop using the robot "thymio ii": The effect on the understanding by children pp. 24–29 (05 2012). https://doi.org/10.1109/ARSO.2012.6213393

9. Mondada, F., Bonani, M., Raemy, X., Pugh, J., Cianci, C., Klaptocz, A., Magnenat, S., Zufferey, J.C., Floreano, D., Martinoli, A.: The e-puck, a robot designed for education in engineering. Proceedings of the 9th Conference on Autonomous Robot Systems and Competitions **1**(1), 59–65 (2009), http://infoscience.epfl.ch/record/135236
10. Razzouk, R., Shute, V.: What is design thinking and why is it important? Review of Educational Research **82**, 330–348 (09 2012), https://doi.org/10.3102/0034654312457429
11. Toh, L.P.E., Causo, A., Tzuo, P.W., Chen, I.M., Yeo, S.H.: A review on the use of robots in education and young children. Journal of Educational Technology & Society **19**(2), 148–163 (2016), http://www.jstor.org/stable/jeductechsoci.19.2.148
12. Vitanza, A., Rossetti, P., Mondada, F., Trianni, V.: Robot swarms as an educational tool: The thymio's way. International Journal of Advanced Robotic Systems **16**, 172988141882518 (01 2019). https://doi.org/10.1177/1729881418825186
13. Wang, M.T., Degol, J.L.: Gender gap in science, technology, engineering, and mathematics (stem): Current knowledge, implications for practice, policy, and future directions. Educational Psychology Review **29**(1), 119–140 (Mar 2017). https://doi.org/10.1007/s10648-015-9355-x, https://doi.org/10.1007/s10648-015-9355-x