Nomination of the RockStartIT project at Karlsruhe Institute of Technology for the 2023 Minerva Informatics Equality Award

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2 Abstract

The Interdisciplinary Didactics and Informatics Departments of the Karlsruhe Institute of Technology (KIT) in Germany have collaborated since 2018 with the common objective of reducing the gender diversity gap in STEM disciplines. This collaboration has resulted in the development of the RockStartIT initiative, which focuses on increasing the representation of girls in computer science (CS). Through the initiative, interdisciplinary courses are offered that connect CS with students' individual interests and passions, providing a platform for problem-solving within their chosen areas. As a result, a diverse group of students has been successfully engaged, encouraging them to explore CS. The structure and approach of the RockStartIT program have played a vital role in fostering interest in CS and enhancing understanding of its real-world applications through interdisciplinary problem-solving. By embracing the IDEA (Interdisciplinary, Diverse, Exploratory, and Active) approach, the initiative creates alternative pathways into the field of CS, leveraging the diverse interests of students who may not have otherwise considered CS as a viable option. Since its establishment in 2018, RockStartIT has motivated over 200 female students to actively participate in CS, leading to significant improvements in their long-term interest and future aspirations. Recognition with the 2023 Minerva Award would serve to raise public awareness and garner support for our ongoing efforts to promote women in CS. Moreover, the award would provide us with the means to expand the program to other countries and institutions, thereby facilitating greater access and opportunities for young women interested in pursuing CS.

3 Description of the Initiative

An opinion piece by Dr Klawe and Dr Shneiderman [1] called for computer scientists to collaborate with other disciplines in order to attract the brightest students, inspire public interest, and expand resources. This call for collaboration is even more important today, as society relies heavily on interdisciplinarity and transdisciplinarity for research and technological progress [2]. Interdisciplinary courses are not only thriving, but vital for the growth and continued survival of computer science (CS).

One reason why interdisciplinary courses can be beneficial for motivating girls to study computing is that they provide context for the material being taught, making it more relatable and meaningful. Interdisciplinary courses can also break down stereotypes about who can succeed in the field, showing that anyone can use and understand computing in many different ways. This can help to make the field more accessible and inclusive, opening up a wide range of career opportunities for girls in fields such as game design, virtual reality, and digital art.

CS education needs to pay special attention to the opportunities offered by interdisciplinary learning and teaching. The traditional CS curriculum is ineffective in promoting female interest in CS because girls find it challenging to identify with CS as such. By tapping into their personal interests and creating interdisciplinary subcultures that resonate, all students can learn CS without feeling trapped by the dominant culture associated with the field today. It is essential that CS education keep pace with the ubiquitous computing-driven progress and innovation in the real world by offering students experiences that mirror this progress and innovation.

4 IDEA Concept of RockStartIT

RockStartIT is an initiative that seeks to provide innovative and engaging online courses. To ensure that our courses are effective, we have defined the IDEA (Interdisciplinary, Diverse, Exploratory, Active) concept based on previous research [3, 4]. This concept consists of four key elements that form the basis for all of our courses (see Fig. 1), and that we continuously seek to improve:

Interdisciplinary All of our courses are interdisciplinary. This means that they connect topics from different domains to provide students with authentic and meaningful learning contexts. The interdisciplinary nature of our courses enables students to explore and connect with their own interests, fostering a sense of personal relevance and motivation that enhances their overall learning experience.

Diverse By incorporating a variety of didactic principles, such as differentiated task levels, adaptive learning techniques, and interactive multimedia resources, our courses provide a tailored learning experience that caters to the unique needs and preferences of each student. This approach promotes individual growth, fosters self-paced learning, and allows students to engage with the course material in a way that best suits their learning style, ultimately maximizing their comprehension and retention of the content.

Exploratory The exploratory nature of our courses empowers students to embrace curiosity, take intellectual risks, and delve into uncharted territories, nurturing their creativity and enabling them to uncover innovative approaches for tackling complex challenges and contributing to meaningful solutions.

Figure 1: IDEA concept of RockStartIT

Active Finally, we , using various activating concepts ranging from simple multiple choice questions to open programming or designing tasks. We foster active learning in our courses by implementing a diverse range of engaging and activating concepts, spanning from simple multiple choice questions and interactive discussions to collaborative projects and real-world case studies such as programming and designing tasks, empowering students to actively apply their knowledge and skills, cultivate critical thinking abilities, and develop practical expertise in their chosen fields.

5 Unleashing Learning Adventures: From Simple Online Courses to Captivating Expeditions

The content of RockStartIT is structured in different domain- connecting courses, so-called "expeditions". They are called expeditions, because students are not just learning the content; it is much more about starting an immersive journey, getting involved in a problem statement, and exploring new knowledge and techniques to make a change and solve real-world problems. We aim to lead students through learning experiences in which an exciting setting, question or challenge inspires curiosity. Students naturally experience exploration by asking and answering questions using CS methods, technologies and data. This means that we form together a motivating question or hypothesis that triggers the need, for example, to collect or analyse data by student, where the student should apply CS methods and technologies to reason, make observations, evaluate, and draw conclusions about the inquiry question. Thus our goal is to learn CS by doing science that engages scientific investigation. This is a means to provide a better illustration of what is and what to expect from CS than traditional siloed introductory CS courses.

All of our expeditions are inspired by topics that, at first glance, are often rooted in other domains but offer the potential to illustrate the strengths of CS and its applicability to achieve more extraordinary things. Our vision is to provide a comprehensive variety so that every student can choose a suitable start in CS connected to their personal interests. In tho following, three of our expeditions are outlined (available at rockstartit.com):

Beyond Biology - Save the Bees In this series of expeditions, students explore the application of technology to solve significant challenges such as colony collapse disorder. The program combines STEM and biological phenomena with CS, enabling students to understand complex issues and create new knowledge. By participating in six expeditions, students experience scientific ways of working and inquiry-based learning. The first expedition introduces the biological background and the problem statement of "How can we help the bees?". In the second expedition, students learn the basics of web development and build a website to inform people about the problem. The third expedition focuses on data science, teaching students about suitable data storage strategies and how to use SQL to search for answers. The fourth expedition investigates if all bees that leave the hive also return and how AI can help count the bees. In the fifth expedition, students become project managers and learn about the benefits of building a team to approach big problems.

Beyond Physics - In Search of Other Life In the physics-related expeditions series, students go on expeditions to search for extraterrestrial life. They start by learning the basics of rocket science to get their rocket into space. They write a program for their rocket using scratch projects, learning about control structures and variables. Next, they learn about camera sensors and signal processing using time-lapse photography. Then they learn how to digitize and store images as pixels before exploring error correction mechanisms to send the images back to Earth without interference. With their newfound knowledge, they can securely transfer their images and set the stage for future expeditions.

Beyond Geography - Save the Climate In this course, students explore computational thinking concepts through the lens of climate change. The course is designed to be integrated into various subjects, with a focus on motivating students to make a real-life impact on the environment. Through a fictional character named Ida, students learn how to live a climate-friendly and sustainable lifestyle. The first expedition introduces fundamental principles of computational thinking, and how they can be used to solve big problems such as the greenhouse effect. In the second expedition, students learn about sustainable nutrition by sorting legumes using decomposition and bucket sorting. In the third expedition, students explore information coding, such as supermarket bar codes, to label fruits and vegetables seasonally for sustainability.

6 Evidence of the Impact

Running Programs Courses of RockStartIT are already in use of several different programs (see Table 1). Until now, more than 300 students of secondary school have enrolled in the project courses. This allows us to collect evaluation data and feedback from many different sources, making optimising our project for both informal and formal education.

Program	Type	Participants	
		female	male
Gender Equity (KIT)	research project	14	32
IT Mission (KIT)	research project	50	51
Girls Day (KIT)	workshop	14	0
Science Camp (KIT)	workshop	12	0
MINT Feriencamp (Cyberforum)	workshop	14	10
Burg Liebenzell (ZLB)	workshop	28	0
Secondary schools	lessons	65	62
Other	lessons	8	18
Total		205	173

Table 1: Participants on courses of RockStartIt in duration of January 2022 to September 2022

Insights on the impact of RockStartIT For evaluation, we use in most of the programs a pre-test-post-test design [5] to measure the impact of our project and to collect feedback. The instrument we use is a self-developed questionnaire that consists of 28 items extracted from a comprehensive literature review [6]. Eighteen items are repeated identically in the pre-test and post-test context to assess interest and attitude changes. Without going into detail here, Fig. 2 and Fig. 3 show example items of the questionnaire and responses from female students on how they have experienced the expeditions. The responses shown indicate that most girls have much fun engaging with the topics and activities of RockStartIT. On the one hand, participating students show an increased curiosity for CS, and on the other hand, they also clearly state that school would be more fun if they would do things as they do in the course more often. At the same time, responses on item *"I like to combine knowledge from different fields to solve problems"* clearly indicate that students in high school enjoy interdisciplinary learning.

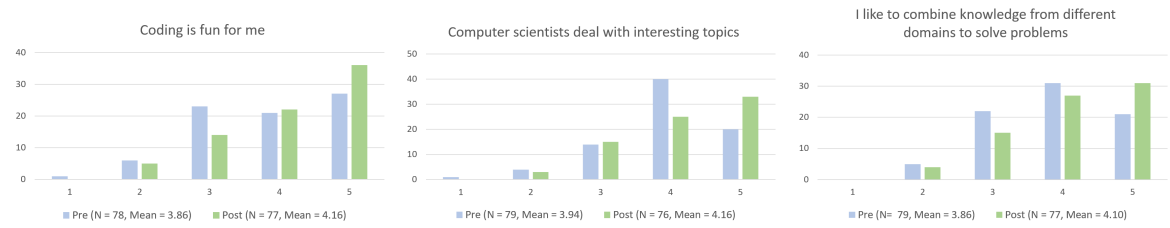

Figure 2: Responses from female participants to selected items on a likert-type scale (1) - Strongly Disagree to (5) - Strongly Agree

Participating in courses of RockStartIT even seems to increase the preference for interdisciplinary learning. In a recent study on the *Save the Bess Expeditions* we also found evidence, that the interdisciplinary nature of the expedition does not only show potential to have a positive effect on girls' attitudes but also to engage a more diverse audience in general including students of all gender, students with less self-confidence in CS, and students that showed programming aversions [7]. So the courses might be an excellent opportunity to enrich traditional school lessons, giving new possible connection points to identify with the subject and get curious about what one can do with CS. This is also reflected in the survey feedback we get from students. One student said, *"It's always fun and it's nice to learn here."*, and another *"I love the website. You learn a lot of new things. It is very interesting and great design."*, which are just examples of the overall opinions. Participants also appreciate the free space the courses give them to progress at their own speed, as this feedback illustrates: *"I liked that we could work very freely"*.

The t-test analysis indicates that the interdisciplinary courses have the potential to further increase general interest in CS (see Table 2:Interest-all). The responses on the item *"Coding is fun for me"* suggest an increased

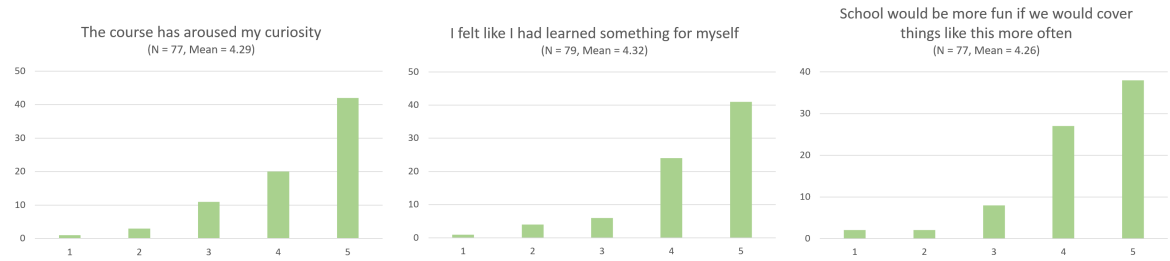

Figure 3: Responses from female participants to selected post-test-only items on a likert-type scale (1) - Strongly Disagree to (5) - Strongly Agree

Table 2: Paired t-tests for pre-test (1) to post-test (2) results by group

Construct (related survey-items)	Group	N	M_1	M_2	SD_1	SD_2	Cohen's d	95% CI Lower	95% CI Upper
Interdisciplinary preferences (*"I like to combine knowledge from different domains to solve problems"*)	all	126	3.91	4.13	0.85	0.85	-0.32**	-0.50	-0.14
	girls	77	3.84	4.10	0.89	0.90	-0.37**	-0.60	-0.14
	boys	48	4.00	4.15	0.77	0.77	-0.24	-0.52	0.05
	coding aversion	16	3.56	3.88	0.89	0.89	-0.44[1]	-0.95	0.08
	low initial self-efficacy	12	3.50	3.58	1.00	1.08	-0.16	-0.73	0.41
	low computer affinity	40	3.73	3.85	0.99	0.98	-0.19	-0.51	0.12
Interest (e.g. *"Computer scientists deal with interesting topics"*, *"What I learn in CS I know I can put to good use later on"*)	all	122	4.07	4.18	0.65	0.66	-0.21*	-0.38	-0.03
	girls	76	3.99	4.08	0.70	0.70	-0.17	-0.40	0.06
	boys	45	4.18	4.32	0.56	0.56	-0.26[1]	-0.56	0.04
	coding aversion	16	3.60	4.04	0.86	0.69	-0.74*	-1.28	-0.17
	low initial self-efficacy	11	3.40	3.75	0.80	0.89	-0.45	-1.06	0.18
	low computer affinity	37	3.97	4.10	0.62	0.69	-0.20	-0.52	0.13

[1] $p < .1, *p < .05, **p < .01, ***p < .001$

acceptance for coding t(121)=-3.00, d=-0.27, p=.004, and responses on the item *"I can see myself doing something in the field of CS later on after school"* indicate a positive effect on future intentions t(122)=-2.15, d=-0.19, p=.033. Additionally, the results indicate a statistically significant effect of the courses on positively impacting students' interdisciplinary learning preferences (d=-0.32, p<.001). When considering the gender of participants, the results show no statistically significant difference between girls and boys regarding the courses' impact on positive feelings, future intentions, and interest in CS ($|d| < 0.1$, $p > .6$). The results were particularly striking in girls' interdisciplinary learning preferences (d=-0.37, p=.002) and also indicated an improvement in girls' self-efficacy (d=-0.19, p=.096).

Our findings support the claims that interdisciplinary education can be an effective approach for increasing interest, and engagement in CS, and addressing diversity in CSEd [3, 4, 6–8]. The results also indicate, that the majority of students in the sub-groups identified as having coding aversion and low initial self-efficacy are female, which highlights the importance of promoting a positive image of coding and strengthening self-efficacy to make students feel comfortable and confident in the field of CS. This observation is further supported by findings presented in [4], which indicate that girls' first contact with CS typically happens in the presence of more experienced learners, typically boys who tend to have a one-year head start in computer usage due to their strong focus on one discipline. As a result, girls often struggle and feel uncomfortable, leading to aversion towards typical CS course activities, such as coding, and low self-efficacy. The results of our study also show that the courses had a striking effect in increasing girls' interdisciplinary learning preferences. This aligns with previous studies that have shown the benefits of learning environments that embed topics into a broader context and involve creative and problem-solving skills, particularly for underrepresented groups in STEM [9].

7 Supporting Letters

- Support letters by 2 high schools applying RockStartIT courses in their lessons
- Support letters by 3 organisations empowering women in IT using RockStartIT courses

References

[1] M. Klawe and B. Shneiderman, "Crisis and opportunity in computer science," *Communications of the ACM*, vol. 48, no. 11, pp. 27–28, 2005.

[2] C.-M. Dabu, "Computer science education and interdisciplinarity," in *Science Education-Research and New Technologies*. IntechOpen, 2017, pp. 137–151.

[3] L. Happe, B. Buhnova, A. Koziolek, and I. Wagner, "Effective measures to foster girls' interest in secondary computer science education," *Education and Information Technologies*, vol. 26, no. 3, pp. 2811–2829, 2021.

[4] L. Happe and B. Buhnova, "Frustrations steering women away from software engineering," *IEEE Software*, vol. 39, no. 4, pp. 63–69, 2022.

[5] D. M. Dimitrov and P. D. Rumrill Jr, "Pretest-posttest designs and measurement of change," *Work*, vol. 20, no. 2, pp. 159–165, 2003.

[6] K. Marquardt, I. Wagner, and L. Happe, "Engaging girls in computer science: Do single-gender interdisciplinary classes help?" in *ICSE '23: Proceedings of the 45th International Conference on Software Engineering Association for Computing Machinery, New York, NY, United States*, 2023, accepted.

[7] K. Marquardt and L. Happe, "Saving bees with computer science: a way to spark enthusiasm and interest through interdisciplinary online courses," in *Proceedings of the 28th ACM Conference on Innovation and Technology in Computer Science Education*, 2023.

[8] ——, "Exploring effects of online and face-to-face teaching formats on students' interest and engagement," in *Proceedings of The 18th WiPSCE Conference on Primary and Secondary Computing Education Research (WiPSCE '23), ACM*. Association for Computing Machinery (ACM), 2023.

[9] R. Tytler, G. Williams, L. Hobbs, and J. Anderson, "Challenges and opportunities for a stem interdisciplinary agenda," *Interdisciplinary mathematics education*, pp. 51–81, 2019.