Enhancing Girls' Feeling of Belonging to Computer Science

Possibilities of Interdisciplinary Online Courses to Increase Diversity of Learning

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ABSTRACT

Computer science education at its current state lacks sufficient opportunities for young women to identify themselves with the subject. My research involves the investigation of interdisciplinary online courses enriched with gamification elements to create engaging learning environments that promote diversity in computer science education.

CCS CONCEPTS

• **Social and professional topics** → *Gender*; • **Applied computing** → **Education**.

KEYWORDS

E-Learning, Interdisciplinary, Gamification, Women, Diversity, K-12, Computer Science Education

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1 CONTEXT AND MOTIVATION

Hardly any other scientific discipline has gained as much importance in recent years and has had such a rapid impact on people's everyday lives as computer science (CS). Career starters with a CS education are in high demand. They have a wide range of opportunities to pursue a career, most of which are very well paid. Since the technologies of CS will increasingly determine everyday life in the future, it is all the more important that all groups of society are equally involved in its development.

Yet, women remain very underrepresented in STEM-related occupations [4]. At the KIT fewer than one of five CS graduates are female. In response to this issue, over the past years, there has been an ever-increasing number of different interventions, specifically dedicated to empowering girls and young women in STEM fields. Although such interventions have now been in place for over two decades, there has still been no significant improvement [1, 15]. This illustrates the need for rethinking the way CS is introduced and taught especially in early education of primary and secondary school. The research presented here is focused on investigating new approaches of interdisciplinary CS education in K-12 combining e-learning and gamification elements.

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2 BACKGROUND

The early teenage years are decisive in setting the course for what topics children will be interested in over the long term. Already in the first years of secondary school, there are clear differences in the perception and attitude of boys and girls towards CS [12]. Reasons for this are diverse. Negative stereotypes, social environment, and differences in prior experience are just a few reasons that lead to learning environments from which some (i.e. often boys) benefit better than others (i.e. girls and novices) [16]. While boys are often motivated by coding and games, girls are not as much interested in these types of learning and practicing CS [15]. CS education at its current state does not provide sufficient opportunities to a majority of girls to identify themselves with the subject and to raise synergies with their interests [14]. Happe et al. [7] provide a comprehensive review of strategies for addressing the gender diversity issue in CS education. In response to these findings, three main effects are considered as impactful solution possibilities.

First, *interdisciplinary* learning units offer alternative pathways into new topics by engaging versatile points of view, often closely related to everyday life. This opens up the view of the big picture and allows students to develop within their abilities and interests. Students are so more likely to feel successful in CS and to explore the relevance of the topics for themselves and in relation to later application situations [13]. There is much evidence that interdisciplinary project work increases student engagement and enthusiasm [10, 13]. Especially girls could benefit from alternative pathways that demonstrate how CS topics are connected to their interests in other domains [6]. CS classes that promote large-scale and creative thinking show to increase girls' confidence for pursuing STEM fields after school [10]. Second, *E-Learning* shows high potential to contribute to the challenge of differentiation in CS education by providing attractive exercises with immediate, personalized feedback [5]. One way of extending e-learning into education are Massive Open Online Courses (MOOCs). Such courses provide students protected space to progress at their own pace and without competitive pressure. They also allow adaptive differentiation through individualized learning paths. All these features support self-regulated learning (SRL) environments, which show to have a positive impact on students' learning performance and satisfaction [3]. Third, *Gamification* extends on the strengths of e-learning by adding game mechanics to the learning process. Gamified learning environments

	digital-only	in-person
without gamification	SC1	SC2
with gamification	SC3	SC4

Table 1: Study Group Classes Overview

show an improvement in students' motivation, engagement and academic achievement [9], but there are observed differences between the effects on boys and girls [11].

3 PROBLEM STATEMENT

Only scarce studies exist that investigate e-learning benefits for gender-sensitive CS education and even less that also include effects of interdisciplinarity and gamification. The hypothesis of my research is that those elements form an impactful foundation for addressing diversity in CS classes and for improving engagement and enthusiasm over the long-term. Accordingly, my research is guided by the following research questions (RQ):

- RQ1: How is girls' attitude towards CS affected when CS topics are introduced through interdisciplinary online courses?
- RQ2: In what ways can gamification in K-12 education increase the engagement of girls for CS?
- RQ3: What are the challenges and opportunities to approach a mutual relation of self-regulated online learning and teaching in-person?

4 RESEARCH GOALS

As part of a gender equity project, the long-term goal of my study is to provide new contributions for the improvement of gender balance in CS-related education and careers. In the short term, the research goals include the development and implementation of interdisciplinary online courses to engage and motivate especially young girls of grades 5 to 10. By conducting courses in digital-only as well as in-person classes, I aim to provide new guidelines for how traditional school lessons can be successfully enhanced with interdisciplinary, e-learning teaching. In addition, I want to evaluate different gamification approaches in consideration of gender to identify strategies especially girls will benefit of (e.g. less competitive systems) and thus, to contribute differentiated opportunities of gamification to promote diversity of learning.

5 RESEARCH METHODS

This research uses a mixed method approach to investigate individual aspects of the problem in respect of their complementary synergies [2]. Quantitative data from pretests and posttests allow comparison of interest, motivation and attitude changes through an intervention taking learners' background into account. Therefore, questionnaires based on the person-object-theory of interest by Krapp/Prenzel [8] are rolled out to the students right before and after an intervention. In addition, qualitative data from observations are systematically acquired and related to quantitative data results. The interventions are conducted at schools or workshops in Germany both in-person or in digital-only scenarios. Accordingly, study groups can be grouped in four classes shown in Table 1.

6 CONTRIBUTIONS

Different interdisciplinary online courses have been developed already and are now freely available (at https://rockstartit.com/). At the current state, these courses are involved in several case studies of SC1 and SC2 with approx. 200 students. For the quantitative evaluation, a new yet unpublished "Computer Science Enthusiasm and Interest Scale" (CSEIS) was developed. In the next step this, research aims to provide a profound overview of the current state of digital instruction design with gamification. This will form the basis for enriching the courses with suitable gamification elements and therefore for case studies of SC3 and SC4 in future research. With those contributions, this study is expected to reveal new insights into opportunities to enhance CS education for diversity.

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