The Design of a High School Computer Science Learning Platform based on Student Modelling

Facilitating Classes without a Qualified Computer Science Teacher in the Netherlands

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ABSTRACT

Dutch secundary schools struggle to find computer science teachers, and employed computer science teachers are retiring. Co-Teach Informatica facilitates computer science education for schools that do not have a qualified teacher. To facilitate their education, an innovative learning platform will be developed. Aside from offering learning materials, exercises and communication with teaching assistants, the platform will support learners and teachers by giving them insight in the learning progress of the learners. Using a knowledge graph with connected learning goals and activities, a student model can be build. This poster introduces the design and research plans for this project. The first experiment will take place in the beginning of 2023, when high school learners will use a prototype of the platform for multiple weeks.

CCS CONCEPTS

• **Applied computing → Computer-assisted instruction**; **Interactive learning environments**; *Learning management systems*; *E-learning*.

KEYWORDS

computer science, secundary education, learning platform, student model

1 INTRODUCTION

In Dutch upper secondary education, computer science is an elective subject. Computer science is offered at the havo (senior general secondary education) and vwo (pre-university education) levels. A collection of learning goals forms the curriculum, which is in line with the Dutch approach to let the government define the learning goals, and let teachers decide how these goals are achieved. The learning goals are grouped into domains, of which some are elective and others are mandatory. In 2019, the computer science curriculum has been reformed and modernized [1].

Although computer science is an important subject to prepare learners for future jobs, it is not offered in many schools. Computer science has the largest teacher shortage of all school subjects: one out of four vacancies cannot be fulfilled, and it is expected that this number will even grow up to 60%. One of the causes of this increasing shortage is that teachers are retiring [2].

Different projects aim to help schools to be able to offer computer science without a qualified computer science teacher. One such project is Co-Teach Informatica (https://www.co-teach.nl/). Their course covers both the mandatory and a selection of elective domains from the computer science curriculum. IT professionals teach the elective domains with the help of a teacher from another subject (school teacher). The mandatory domains are offered via online materials from different sources and publishers, with the remote support of the local support desk. The local support desk consists of teaching assistants and a subject didactics expert, and supports schools within a certain region.

To support a student model based approach and enhance independent learning, a new platform will be developed. This does not only include offering learning materials, exercises and communication with the local support desk, but also helps learners to reach the desired knowledge level. The platform includes a knowledge graph of all learning goals in the computer science curriculum. This can be used to build a student model and recommend tasks or activities to fill knowledge gaps of students. This central role of learning goals and a detailed student model is a new approach to building a learning platform.

The project presented in this poster focuses on the design of the platform and the recommendations in particular. Together with the different user groups, the requirements are explored, which is explained in more detail in Section 2. More details on the role of learning goals and recommendations in our platform can be found in Section 3. Section 4 describes the pilot experiment that is planned in the beginning of 2023, in which learners will use a prototype of the platform for multiple weeks. The evaluations from this pilot are used to further improve the platform and direct the future of the

project. More on the future of this project and future possibilities of the platform can be found in Section 5.

2 USER GROUPS AND PLATFORM REQUIREMENTS

Nine schools are participating in the Co-Teach Informatica program in 2022-2023. During this year, Badgecraft (https://www.badgecraft.eu/) is used as a study guide, linking to materials of different Dutch educational CS material publishers for the mandatory domains. The teaching assistants from the local support desk correct the students' work and answer questions about these domains. The subject didactics experts from the local support desk offer didactics support to the teaching assistants, school teachers, and guest teachers. Moreover, the subject didactics of all regions work together on the composition of the learning materials.

All these different roles need to be represented in the platform. Thus, the following user groups and demands can be identified:

- *Students* will find their learning materials on the platform, will be able to hand in assignments, which will be corrected by the teaching assistants, and will use the platform to communicate with the support desk.
- *School teachers* will use the platform to monitor the progression of students and to structure the course.
- *Teaching assistants of the local support desks* will use the platform to correct students' work and will be able to answer questions via the platform.
- *Subject didactics expert of the local support desks* will use the platform to prepare the course materials.

Personas (fictional characters representing different user types) are important means that help during the design phase. To create such personas, it is important to gather information from the different user groups. Interviewing the target groups about their experiences during this first year gives a better understanding of what the new platform should look like, both graphically and functionally.

Based on a first exploration with the local support desks and the management of Co-Teach Informatica, a list of important features of the new platform is created:

- Give a clear overview of all relevant learning materials, if possible without external linking.
- Enable communication between all users.
- Allow students to hand in their work, and allow teaching assistants to provide feedback and grade it within the platform.
- Allow users to see the progression of students (depending on the user type).
- Allow all users to see (and edit if relevant) the planning of the course;
- Support the learning process of students by recommending suitable exercises.

3 RECOMMENDING ALGORITHM

As mentioned in the introduction, an important added value of this learning platform compared to other platforms is that it monitors the progression of the students using learning goals structured in a knowledge graph. Every exercise in the platform is linked to one or more learning goals. Learning goals are organised in a large directed graph that structures the knowledge in such a way that for each learning goal relevant prior knowledge is indicated. Once a student completes an exercise, the knowledge score for the linked learning goals, as well as linked prior learning goals, is adapted. In this way, a student model can be built. The algorithm then searches for gaps in the knowledge of students and can then recommend exercises that cover those gaps to strengthen their knowledge. Moreover, this can be a tool for school teachers and teaching assistants to understand each student's strengths and weaknesses, without the need to understand the content (in the case of the school teachers).

The mathematical implementation of the algorithm needed for this feature is still under development and will need testing and tweaking once the platform is used by students. It is possible to adapt this algorithm to make different types of suggestions. Further research might focus on the following aspects related to this:

- Exercise suggestions for groups of students.
- Peer suggestions for students: recommending a peer with complementary or similar knowledge levels.
- Identify which learning goals have lacking coverage in the exercises.
- Identify which learning goals are experienced as difficult by the students.

4 PILOT EXPERIMENT

In the beginning of 2023, a pilot experiment will take place. In this pilot, a prototype of the platform, including as much of the important features as possible, will be tested for (part of) one of the mandatory domains. For this prototype, the platform will be built upon the existing infrastructure of the Digital Mathematics Environment of Numworx (https://www.numworx.nl/en/). In close collaboration with the developers of Numworx, new features are added to the platform.

We expect to be able to run the pilot experiment in a few classes and aim to gather information about the user experience from the different user groups using log data, evaluation forms, and focus groups. In any case, the pilot experiment aims to gather information about the user experience from the different user groups using log data, evaluation forms, and focus groups. It must be noted that studying the effect of the personal recommendations is only useful if there is a sufficient number of students.

5 FUTURE WORK

With the findings of the pilot, the design of the platform can be further improved. Moreover, the content in the platform will be extended with other domains. If needed, new features will be developed. The final goal is that all schools participating in Co-Teach Informatica can use the platform for all mandatory domains.

Although this platform will be designed and used within a specific setting, it could potentially be used in other settings as well. In the Netherlands, there is a shortage of teachers for multiple high school subjects (such as mathematics and physics). The platform could be altered in such a way that it can also be used for other subjects, using the same structure as used by Co-Teach Informatica.

It is important to note that the platform is not meant as a replacement for a teacher. The platform is specifically designed to help to deal with the existing teacher shortage, but could also be used to help non qualified teachers get more insight in the learning domain of computer science and support their professional development.

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