Context-related programming tasks to reduce the digital gender gap

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Abstract. This article aims to put a learning concept up for discussion, which is based on context-based access. We describe a concept designed to inspire girls in particular with regard to information technology. Problems from the field of medicine motivate pupils to create self-designed algorithms with the goal of helping people. Through positive self-efficacy experiences, this access is intended to facilitate the engagement with digital technologies. In this way, we aim primarily to reduce the gender gap in computer science that is described in the literature. We offer concrete teaching examples within a framework of informatics at Secondary Level 1, which are intended to help appeal to more girls in computer science lessons.

Keywords: context-based programming tasks, digital gender gap, social context, medical context

1 Introduction

The literature suggests a gender imbalance in computer science to the disadvantage of girls. If the creation of self-designed algorithms is considered a digital skill, then the gender gap thus also holds for the area of digitalization. In our article, we would therefore like to put an approach up for discussion, according to which it might be possible to reduce the existing gender imbalance through suitable learning scenarios. In this regard, we will draw on context-based access, as described in Koubek et al. [1], Diethelm et al. [2] and Knobelsdorf and Tennenberg [3]. In terms of context, we have deliberately chosen the area of medicine. A meaningful, medical context with social aspects, with the motto “Informatics Helps!” is intended to facilitate the engagement with digital technologies and in particular the creation of self-designed algorithms. The aim is to arouse girls’ interest in the technological aspects of the digital world through positive self-efficacy experiences. Initial experiences and research in the literature endorse this approach ([8][10][12]).

However, the incorporation of medical aspects into computer science lessons is complicated (in a small survey) through a lack of acceptance among teachers. In this article, we will therefore demonstrate a practicable solution that is accepted by the teachers in the survey, namely the conception of a computer science pupil laboratory course with medical topics.

2 Digital Gender Gap

The study "Digital Gender Gap" [4] considers among other things the "technological perspective" of the digital world. The difference between 14- to 24-year-old women and men on the question of using (at least) one programming language is greater than 10% (women: 11% (N=112), men: 23% (N=135)). In the future, however, job perspectives will certainly be even more impacted by the digital skills of school leavers than ever before. This also implies a gender gap in everyday working life for future generations.

The Conference of German Education Ministers has published a strategy paper on “education in the digital world” regarding schools [5]. It presents a catalogue of skills to be supported in the field of digitalization, including the competence area: problem solving as well as the handling and creation of simple algorithms. These are also content- and process-related competences of computer science education (compare for example [6]). However, if we look at the gender mix in computer science education, we can find in a study [7] that the number of girls in computer science, e.g. in courses with higher demands in school (11^{th} to 13^{th} grade), lies only between 15 and 20% over the period from 2010 to 2018, apart from short-term variations. Thus, we find a great gender gap here as well.

In our project we therefore want to develop learning scenarios with the potential to reduce this gender gap.

3 Ways to get girls interested in computer science and digital technology

Magenheim and Schulte write in their study that there are gender-specific differences in the expectations of computer science education. Accordingly, boys are significantly more often classified in the group of people interested in software development and programming. Girls are more often interested in applications and consequences in computer science education [8]. Every third girl in Germany criticizes that computer science at school is almost always explained with examples from a "boy's perspective” [9]. In current teaching materials, informatics topics and especially the creation of self-programmed algorithms are often taught based on mathematical and technical examples. We adopt these findings of Magenheim and Schulte and create learning environments that embed the creation of self-designed algorithms into a medical context. Under the motto "Informatics Helps!" we want to use solution strategies of informatics to help people. In this way, we link the creation of self-designed algorithms with social aspects. We find support in the literature [10]. Women account for 19.4% of all computer science students. However, the proportion is clearly dependent on whether it is a "pure" computer science course or whether other (sub)subjects are added. In traditional computer science, only 16.5% are women, whereas the percentage of women in medical computer science is 43.2%. [10]. The mixture of “pure” computer science topics with more application-based subjects seems to be a possible way to achieve a more balanced gender relation [10]. Thus, this form of learning scenarios can be helpful in reducing the gender gap in computer science.

4 The context-based approach

The ways of thinking, strategies and tools of computer science are used to solve problems that occur in other (life) areas. Pupils do not solve inner informatics problems but use informatics to solve problems in other areas. The purpose is central.
Initial experiences with the teaching of informatics theories in medical contexts were made in the academic years 2007 - 2010 in a course for grades 7 to 9 at a grammar school. The tasks for the different topics have been published in parts as teaching material [11]. Here, the large number of girls choosing the course (36%, N=28) was surprising, because gender issues had not been considered before. In another computer science course without a medical context at the same grammar school in the academic years 2009 - 2012, the number of girls had decreased significantly (12%, N=25) [12].

4.1 On the acceptance of the context-based approach:

In advance of a cross-school further training measure, participating teachers were surveyed on a selection of Scratch tasks with equivalent levels of difficulty regarding how suitable they considered these to be for their pupils. The teachers were able to rate the individual tasks on a Likert scale ranging from (1) “unsuitable” to (5) “highly suitable”. Tasks with a medical context received an average rating of 2.77 (N=22). Tasks with equivalent levels of difficulty without a specific context were rated 3.64 (N=22). A second survey took place after the first two months of the further training measure, during which the teachers had also engaged with context-based tasks that work well in lessons. On the same scale, the tasks with a medical context now received an average rating of 2.40 (N=21). Tasks with the same level of difficulty in the area of “Games” now received a rating of 3.67 (N=21).

Individual interviews with participants regarding the ratings of context-based tasks gave rise to two problems that evidently influence acceptance:

- Context-based tasks are too text-heavy for pupils, because the context requires clarification.
- One concern of the teachers is that they do not have enough specialist knowledge with regard to the relevant context. In their view, a time-consuming familiarization with the context would be required.

In order to ameliorate the first problem, a one-minute film was recorded by the author, in which the context and the problem definition were clarified. Here, the same task was intentionally used and posed again in text form. The suitability of the task in text form now received a rating of 2.7 (N=24); thus, there was no change vis-à-vis the first surveys. By contrast, the teachers rated suitability of the film for the pupils considerably better, with a rating of 3.5 (N=24).

With regard to the second problem, the author considered outsourcing the context to a pupil laboratory course. The course was meant to be oriented towards the current informatics knowledge of the pupils, but to be embedded in a medical context. The teachers were introduced to the course conception and were asked whether they agree with the following statement (1: “I do not agree” to 5: “I agree completely”): “**One-off** experiences, such as a visit to a pupil lab course on medical informatics, can show pupils that the things taught and learned at school are relevant and relate to everyday life.” The average rating of 3.75 (N=24) is higher than the film version.

The course conception can be found in the following chapter. The beginning of the courses was imminent. Due to the Corona crisis, however, we will only be able to carry out the evaluation in the next academic year; as such, we do not yet have any results.

5 Course conception “Informatics helps!”

We have designed a medical informatics course for pupils of grades 9 to 10, which we intend to offer via the Experimental Laboratory for Young People (XLAB) at the University of Göttingen in cooperation with the Medical Informatics Research Group [13]. On the informatics side, this course is aimed at creating self-designed simple algorithms and building small informatics systems with the help of a sensor board (Calliope [14]) and suitable sensors. The tasks at the individual stations are designed to be flexible. Thus, the pupils can go through a creative and individual process of creating their own algorithms. Very simple solutions in particular are always possible. Thus, the participants are successful in fulfilling the tasks in any case. The pupils are trusted to (re)construct a real, complex informatics system, which strengthens their self-efficacy. Furthermore, after finishing all tasks, they can be proud of having created self-developed and fully-functioning informatics systems. In this way, we show them a certain appreciation of their skills. The pupils are taken seriously as problem solvers.

The course will incorporate the following five stations:

- Image analysis of ultrasound images (e.g. create an algorithm for marking points on an ultrasound image. The size of an embryo, for example, can then be measured automatically) (see Fig. 1).

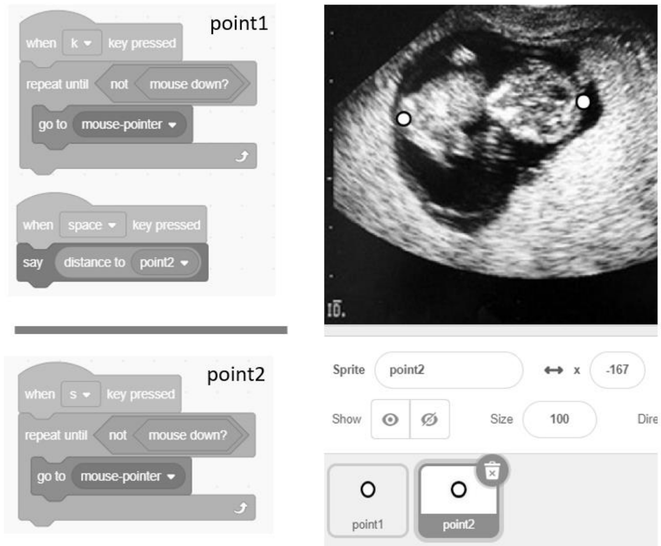

Fig. 1. Image analysis of ultrasound images

The real ultrasound device provides a reference to the real world. As most ultrasound examinations involve the measuring of specific lengths or areas on the ultrasound image, it is even likely that some pupils in the learning group can recall this situation. In addition, films showing this examination are presented on a display, so that the examination method is transparent. Digital ultrasound images are uploaded onto a Scratch 3 platform. The pupils thus program (in a didactically reduced way) a system with similar functionality as in a real application. This represents an experience that can contribute to a strengthening of the pupil's sense of self-efficacy.

- **Development of a heat monitoring system for newborns** (e.g. create an algorithm that uses different coloured lamps to provide feedback on whether the temperature in the warmth bed is too high or too low.)

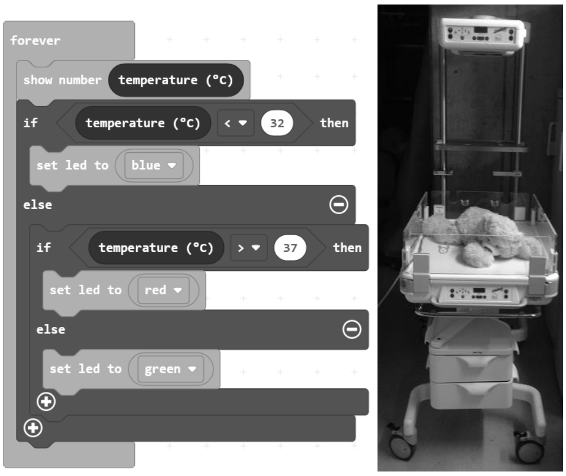

Fig. 2. heat monitoring system for newborns

As can be seen in the figure 2, this algorithm can be solved simply and does not require any additional sensors for the Calliope. A refined visualization of the temperature is conceivable. The warmth bed in the figure makes the helping aspect more tangible. An integrated warmth lamp facilitates the testing of the program, as there are different temperatures in the bed.

- **Development of a diagnostic software for the ophthalmologist** (e.g. create an algorithm that automatically displays the Landolt C Eye Chart in different rotations and sizes) (see Fig. 3).

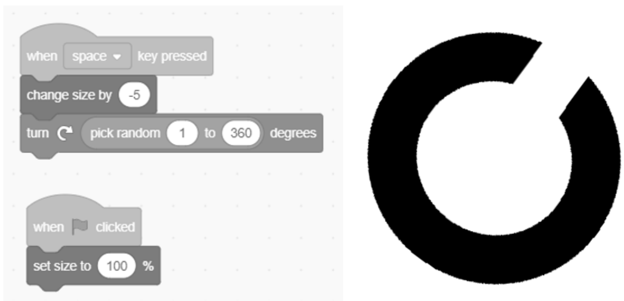

Fig. 3. diagnostic software for the ophthalmologist

As the figure demonstrates, this task can be solved very easily. By contrast, entire eye charts with progressively decreasing Landolt rings or only specific rotations are more complex in terms of programming. This supports the ophthalmologist, as patients may rote learn the direction of a fixed eye chart after several trials, and a computer program can allow greater flexibility. Posters with explanations of near- and far-sightedness create an even stronger reference to real life applications which creates links with the areas of optics or biology.

- **Developing a computer system for a resuscitation phantom** (e.g. create an algorithm that reports whether the compressions are done in the correct beat, e.g. create an algorithm that provides feedback on the compression depth).

A part of this station is illustrated in the following figure (Fig. 4). By creating the algorithms, the learners use didactically reduced resuscitation phantoms. Real resuscitation phantoms and posters with information on first aid and current research in this field create the real-life relevance for this application. An external pressure sensor for the Calliope board is required. The figure shows a part of a possible implementation (Fig. 4). This requires initial knowledge of the area of algorithmics, e.g. the function of a "flag". By combining complex problems and those that can be solved more simply, the heterogeneity of each learning group is accounted for.

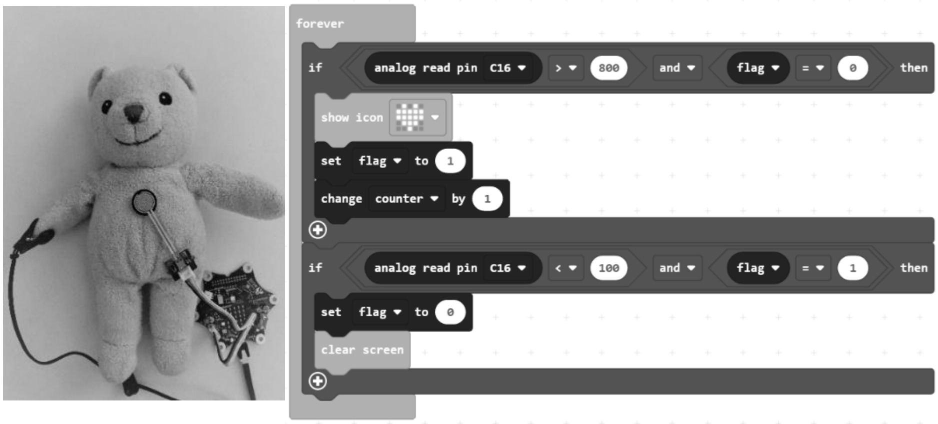

Fig. 4. computer system for a resuscitation phantom

- **Development of a simplified heart rate monitor** (e.g. create an algorithm that measures and displays the data of a heart rate sensor).

A heartrate sensor for the Calliope board like the one in the figure (Fig. 5) will be made available to the pupils. From the perspective of algorithmics, this station is comparable to the resuscitation phantom.

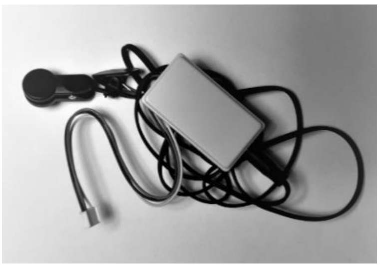

Fig. 5. sensor

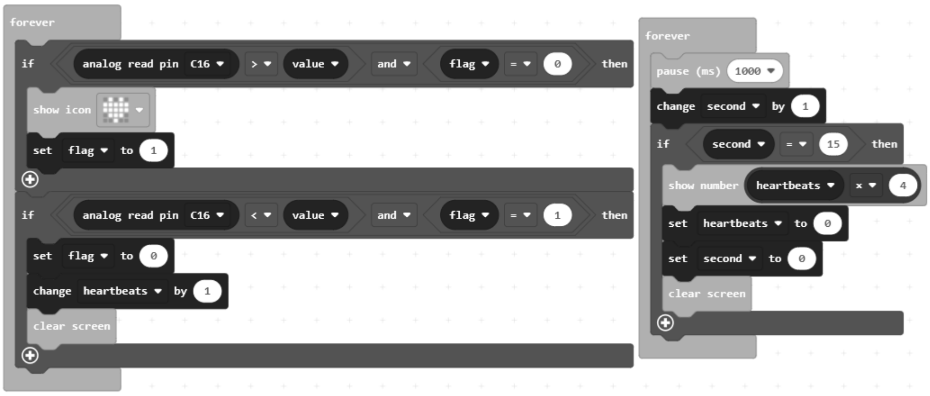

Fig. 6. simplified heart rate monitor

6 Conclusion

Can girls be better addressed in the field of informatics and thus also in digital education by embedding informatics problems into a medical and social context? Is it possible to reduce the digital gender gap at school by giving girls access to other areas of computer science through self-efficacy experiences in appropriate learning scenarios?

Our initial experience and a literature search suggest an affirmative answer. We outlined the course conception of an informatics course with a medical context, which releases teachers from the time-consuming familiarization and organisation of context-based material in Chapter 5. An evaluation can only take place when visits to the student laboratory are possible again after the Corona crisis.

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