Investigating Teachers' Diagnostic and Intervention Skills in Debugging

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ABSTRACT

Students often struggle with debugging in the K-12 classroom. Supporting them individually provides a huge challenge for teachers, as they have to grasp the problem, diagnose why the student is stuck, and react with an appropriate intervention without simply specifying the solution in a very short amount of time. To this end, teachers need corresponding diagnostic and intervention skills, a core component of pedagogical content knowledge (PCK). However, such skills – as well as debugging in general – typically only play a minor role in teacher education. Therefore, we present a research project to investigate and foster teachers' diagnostic and intervention skills in debugging. As a first step, we analyzed teachers' perceptions of typical problems students have in debugging and how teachers support them using a persona approach. The first findings reveal some common problems and a spectrum of interventions and feedback teachers use to support students.

CCS CONCEPTS

• **Social and professional topics → K-12 education**.

KEYWORDS

debugging, K12, computer science education, teacher perspectives, diagnostic and intervention skills

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1 INTRODUCTION

Debugging is a core problem of teaching programming, as novice programmers in the K-12 classroom often struggle with finding and fixing errors on their own [4, 7]. In consequence, this provides a challenge for teachers as well. If they are called for help by the students, they have to understand their problem and react with an appropriate intervention. Meanwhile, more students wait for help. As a result, teachers commonly rush from one student to the next, trying to do justice to all the students [9].

The diagnostic and intervention processes involved in this short amount of time are complex: the teachers have to locate the programming error, understand why the student made it, and identify why the student is unable to solve the problem on his own. Afterward, they have to choose an intervention tailored to the student's abilities and level of knowledge, which helps to fix the bug on the one hand and foster self-reliance in debugging on the other hand.

However, teachers have typically not learned debugging systematically, and PCK on debugging is no common content of teacher education [10]. Therefore, their diagnostic and intervention skills result from their teaching practice. Furthermore, empirical results on effective diagnostic and intervention processes are lacking. This raises questions, such as: How is the quality of teachers' diagnostic skills? Do they recognize why students are unable to solve the problem? Which interventions do they apply? Are these interventions efficient? Are there more efficient ones? Addressing these issues we present a research project investigating the diagnostic and intervention skills of teachers in debugging.

2 RELATED WORK

Debugging describes the process of finding and fixing errors in programming. Previous studies have shown that debugging differs from general programming knowledge [1]. Additional skills, such as applying debugging strategies and heuristics for typical bugs are necessary [6]. There is evidence, that explicitly conveying those skills in the classroom successfully fosters students debugging performance and self-reliance [4].

However, for teachers, such content knowledge is not sufficient for improving the quality of their teaching. Additionally, they require PCK [11] for diagnosing students' processes and how to intervene in a particular debugging situation. Tsan et al. [13] investigate teachers' PCK on debugging after professional development using Scratch. They found, that teachers would support their students mostly with a focus on a code level solution, when confronted with buggy code. However, diagnostic processes were not taken into account so far and intervention skills were only investigated in special debugging tasks.

Diagnostic skills can be defined as the ability to accurately judge student characteristics relevant to learning and to appropriately assess the demands of learning activities and tasks [2]. Thus, diagnostic skills are necessary for monitoring students' understanding during the learning process and are relevant for student progress. Concerning debugging, knowledge of students' typical problems is one component relevant in the diagnostic processes. As individual

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students vary widely in the time taken to master a concept [3], teachers have to decide which form of intervention will be most effective [12]. Regarding teaching debugging, diagnostic and intervention skills can be considered essential to support students. However, so far those skills are not addressed systematically.

3 A PERSONA APPROACH

As a first step, we investigated teachers' perceptions of students' problems in debugging and how they support them. Initial data were collected in the context of a professional development workshop on debugging using the persona method [5] with K-12 computer science teachers. In the persona method, data is collected about a group of people and combined to form a profile, the so-called persona. The focus here is often on the goals, motivators, and difficulties of this group. Thus, the teachers had to switch to learners' perspectives to work out these factors for students in the debugging process. To this end, groups of teachers characterized their "typical" students debugging processes, thus providing first insights into their diagnostic skills. Furthermore, we asked the teachers to describe how they would support the respective students in their classroom, assessing common interventions. This way, we gathered ten personas, as shown in figure 1, from about 40 participating teachers. The data were analyzed by applying a qualitative content analysis according to Mayring et al. [8] with inductive category formation.

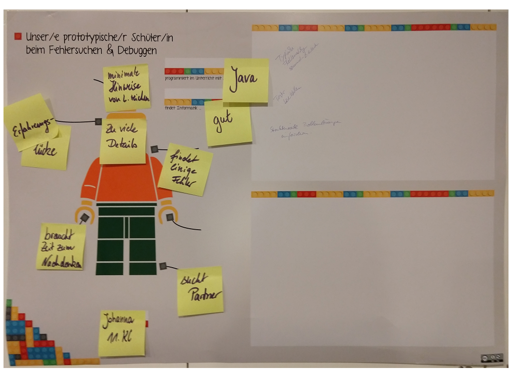

Figure 1: Persona example from the workshop

Teachers reported that the students often struggle in particular with understanding error messages and therefore expecting the errors at the wrong position. Other common themes were students tending to ask the teacher or classmates directly without attempting to solve the problem themselves, as well as a low tolerance for errors resulting in frustration.

Regarding the teachers' interventions, our first findings show a wide variety of approaches and feedback they use to support students in coping with errors. Some interventions have a rather preventive character, such as demanding for structured problem solving by requiring extensive planning, teaching exemplary debugging strategies, or intentionally producing errors in teacher demonstrations to explain the corresponding error messages in advance. Furthermore, many teachers report that they deliberately promote teamwork, often in the form of pair programming. Additionally, some teachers set rules for assistance, such as always trying to find a solution on your own before asking a classmate or the teacher for help. Specifically concerning individual support, teachers' reported commonly explaining basic syntax (variable declaration, missing brackets), code structure (missing formatting or comments), or discussing code execution with students. Some teachers reported solving errors in class by dragging the student's code onto the teacher's computer. To deal with error messages, the teachers' feedback addresses reading the message in detail, translating it, or looking it up.

4 DISCUSSION AND CONCLUSION

Our first findings provide insight, into teachers' perception of typical problems and student behavior while debugging in the classroom. Comparing the results to the literature, we found that teachers reported a subset of novices' common problems in debugging [4]. However, knowledge of typical novice problems is just a part of diagnostic skills.

Regarding teachers' interventions, we found a range of approaches teachers use to meet these problems. The approaches lead to the assumption that the used interventions are self-taught and there is a lack of best practices in teaching debugging. Furthermore, most interventions focus on error avoidance or bug fixing. Only a few aim at fostering students' self-reliance in debugging.

In future work, we aim to investigate the quality of teachers' diagnostic and intervention skills. Furthermore, we want to identify effective interventions or feedback for improving students' debugging self-reliance. The next step is to gather more detailed insights into diagnostic and intervention skills in the classroom by expanding the study as well as using video vignettes of students.

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