# Fostering Diagnostic Skills: Using Video Vignettes in Computer Science Teacher Education

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**Abstract:** Diagnosing student problems in debugging is a huge challenge for computer science pre-service teachers. Therefore, appropriate diagnostic skills should already be fostered during teacher education. Lecturers use video vignettes showing typical teaching situations in other domains to foster diagnostic skills. However, in computer science education, these approaches have hardly been considered. This practical report presents the concept of a teaching format that uses scripted video vignettes to foster the diagnostic skills of pre-service teachers in computer science.

**Keywords:** video vignettes, debugging, teaching format, teacher education

## 1 Introduction

Diagnosing classroom situations is a typical task and an essential skill for teachers. One key diagnostic activity in the K-12 computer science classroom is providing individual support to students during programming and debugging [MR19]. This situation, in particular, presents teachers with challenges, as they typically have to rush from one learner to the next to help due to the significant difficulties that novice programmers have in finding and fixing errors in the code. If a student has an error they cannot solve independently, the teacher must diagnose why the student made the error and why they cannot fix it [HM23]. This task is not easy because the student's problems depend on cognitive, motivational, and metacognitive factors. However, a correct diagnosis is the basis for appropriate intervention by the teacher because only if they have correctly identified the problem they will be able to provide the student with individualized support.

However, diagnostic skills in debugging are rarely part of computer science teacher education but often come from teaching practice[HM22]. Thus, pre-service teachers often have difficulties diagnosing teaching situations at the beginning of their teaching career [CSea20]. Diagnostic skills should, therefore, already be fostered during teacher education [Cea20]. Other domains, such as mathematics education, use video vignettes to foster diagnostic skills in teacher training (cf. [SCea23]).

Video vignettes showing typical classroom situations in debugging can prepare pre-service teachers for the teaching requirements. This article, therefore, presents the concept and experiences from a teaching format for computer science teacher education for diagnosis

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in the classroom using the example of debugging. The teaching format aims to foster pre-service teachers' diagnostic skills for student problems in debugging.

## 2 Background

The diagnostic process assesses situations in which knowledge is applied to solve problems and make decisions [Hea19]. Therefore, diagnostic processes in the classroom include assessing relevant aspects of students' learning [Bea18]. When diagnosing student problems in debugging, teachers undergo a multi-step diagnostic process (cf. [HM23]). Therefore, teachers must recognize and evaluate relevant situation-specific aspects to identify and diagnose the problem. In these two steps, teachers require pedagogical content knowledge (PCK) about typical errors [CK86], misconceptions, and other issues of students in programming [QL17]. They must understand why the student cannot solve the problem independently. Reasons for this could be a lack of content knowledge, interest, or knowledge about problem-solving strategies [MR19, HM22]. Motivational and emotional factors can significantly influence students' debugging process [KS10]. Based on this diagnosis, teachers can anticipate different support strategies that consider the students' abilities and level of knowledge [KDD].

However, in contrast to tool-based approaches of automated feedback to learners in programming, there is limited evidence on diagnostic skills in debugging (or computing education in general). Existing findings mainly focus on investigating how teachers act in the classroom from an "observational" perspective, e.g., Tsan et al. [TWF22]. The authors concluded teachers often supported their students with code-level solutions when encountering incorrect code. Furthermore, Hennig and Michaeli [HM22] investigated teachers' perceptions of typical students' problems and their intervention repertoire, finding explanations of programming concepts and discussing code execution as typical approaches concerning individual support of students. Besides observing teachers in the classroom, Wachter and Michaeli [WM24] used scripted video vignettes to investigate experienced teachers' diagnostic and intervention skills in debugging. In doing so, aspects that experienced teachers pay attention to when diagnosing debugging situations were identified. They found various situation-specific aspects that could be categorized into the levels of content knowledge, problem-solving strategies, and emotional-motivational aspects. However, there are still a few approaches that deal with the teaching of diagnostic skills. Pieper and Vahrenhold elicited twelve domain-specific critical incidents that can occur in K–12 Computer Science classrooms for using them as vignettes in computer science teacher training [PV20]. Weinert and Krone used videos showing the programming processes of secondary school students on the one hand and role plays that address misconceptions of students on the other to train the diagnostic skills of pre-service teachers in training [WK24].

Video vignettes are a common and practical approach to train diagnostic skills in teacher training [GSVE09, Sea22]. As specific teaching and learning behaviors are often challenging to observe in real classrooms, researchers have developed scripted video vignettes to facilitate observing these behaviors. Such video vignettes offer the advantage of providing scaffolding in contrast to the complex situation in the classroom. They can also be viewed multiple times with different emphases to help promote prospective teachers' PCK [GC15]. Further, they can be embedded in digital simulations, which offer *representational scaffolding* (cf. [FBea22]) to facilitate learning knowledge and skills for professional practice. Representational scaffolding is a targeted adaptation of representational aspects - such as informational complexity, typicality, agency, and situation dynamics - to adapt learning tasks in practice environments to the respective level of knowledge of the user. This form of supportive design makes it possible to organize everyday professional situations in simulations so that they are both authentic and accessible to novices. For example, graduated learning on demand is guaranteed by starting the simulation with reduced complexity and clearly structured typical scenarios and gradually adding room for action and dynamic conditions as the exercise progresses. This promotes a well-founded approach to core professional practices, improves the accuracy of learning impulses, and supports structured problem-solving by preventing cognitive overload.

## 3 Concept of the teaching format

The following section introduces our teaching format. It begins with describing the video vignettes we use and then outlines the format.

**Video vignettes:** For the teaching format, we used four scripted video vignettes showing typical debugging situations for two students in the classroom. This allows us to train the pre-service teachers' diagnostic ability in a specific situation. The individual situations are based on the literature and practice. All vignettes have a duration between 1 and 2 minutes. The development of the vignettes is shown in [ZMR23]. The video vignettes each show the behavior, communication, and content of the screen of two students while confronted with a specific error (see figure 1). The authenticity of the video vignettes compared to real classroom situations was confirmed by experienced teachers in a study [WM24]. For all video vignettes, we received confirmation of predominantly realistic classroom situations. The content of the video vignettes is described below.

In all four vignettes, two 11th-grade students implement a Java program in the Greenfoot development environment [2] using pair programming. In *video vignette 1* (*V1*), the two students program a ball. However, their program contains a syntax error and thus can not be executed. The students identify the incorrect class and try to fix the error independently. But they insert the missing bracket in the wrong place. As a result, the semicolon is missing as a closing argument, and Greenfoot returns an error. In *video vignette 2* (*V2*), the students get multiple error messages caused by an erroneous library import. The incorrectly integrated library leads to an error and two subsequent errors when calling the library functions. They

2 https://www.greenfoot.org

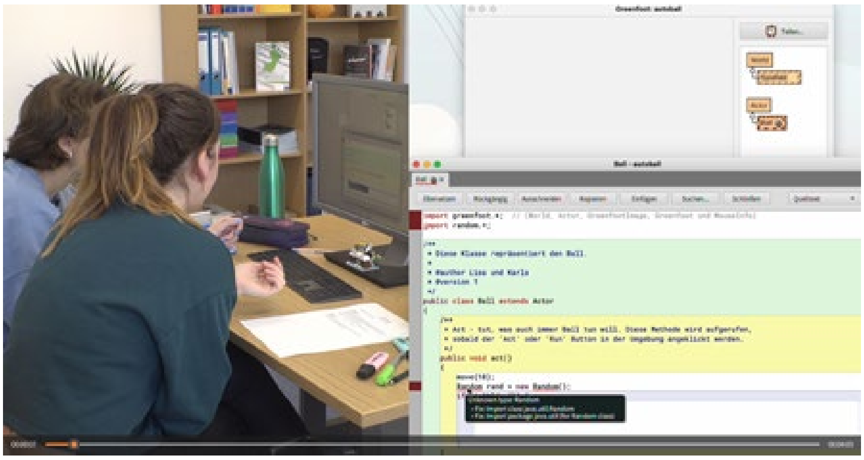

Fig. 1: Screenshot of Vignette

switch between the errors and read the error messages but do not understand them. *Video vignette 3* (*V3*) shows how the students create an object ball and receive a null pointer exception. They do not understand the error message and try to close the window several times. Finally, in *video vignette 4* (*V4*), the students try to implement a boost function for the ball and receive another null pointer exception. The students are unsure about how to proceed since the object exists.

**Structure of the teaching format:** Teaching diagnostic skills is not yet a standard part of computer science education. Prospective teachers' difficulties in diagnosing teaching situations and the lack of practice opportunities have prompted us to develop a teaching format in which pre-service teachers can deal with the diagnostic process and practice diagnosing student problems during debugging. Thus, the teaching format aims to foster pre-service teachers' diagnostic skills by enabling them to deal with the process in a more detailed way, become aware of processes that usually take place unconsciously, and practice the diagnostic procedure in a targeted manner. The teaching format is a 90-minute unit that can easily be integrated into a lecture on computing education. It is intended for students of computer science education who already have a sound knowledge of an object-oriented programming language, preferably Java, since the video vignettes use Java code.

As an introduction to diagnosis during debugging, the pre-service teachers should reflect on their own experiences with individual support during debugging and the challenges they have encountered. The pre-service teachers should then consider what mistakes students typically make when programming and what challenges they face when debugging. These questions are intended to activate existing prior knowledge. Before working on the video vignettes, there is a short input part where the term "diagnosis" is introduced, and we discuss what it means and why diagnostic skills are essential in the classroom. The structure of the rest of the teaching format is based on the steps of the diagnostic process from the process model for diagnosis and intervention in debugging [HM23]. We have decided in favor of this approach to provide pre-service teachers with a concrete procedure for making diagnoses and to guide the pre-service teachers through the process. This process model to make a diagnosis consists of three steps: Recognize, Assess, and Generate. Firstly, the first step *Recognize* is introduced to the pre-service teachers. Recognizing involves collecting typical situation-specific aspects that provide information about the student's problem. Therefore, the first task to work with the vignettes is: "What situation-specific aspects can be found in the video vignette?". Then, the pre-service teachers can write down their suggestions and get the opportunity to share their answers in class or groups. The exchange allows pre-service teachers to broaden their perspective by drawing their attention to other aspects of the vignette that they may have overlooked or considered less important. Situation-specific aspects can be categorized into the levels of conceptual knowledge, problem-solving strategies, and motivational and emotional aspects. The lecturer can now introduce this distinction, and the pre-service teachers can consider where they would categorize the aspects they have found. This concrete examination of aspects sharpens the perception of rarely considered aspects, such as emotional and motivational aspects. Afterward, the next step, *Assess*, is introduced. The collected aspects are evaluated when assessing, and conclusions are drawn about the student's problem. Hypotheses are formed about why they made the mistake and cannot solve it independently. Thus, the pre-service teachers must answer the following question for this step:"What hypotheses can be formed for the student problem shown in the video?" As in the previous step, the answers found are discussed with other pre-service teachers and the lecturer. In the final step, *Generate*, alternative courses of action are generated regarding how a teacher could react to the diagnosis. To do this, the teacher must anticipate courses of action for various possible interventions and assess their influences. Thus, the task for the students is to decide "What alternative actions does a teacher have in the teaching situation shown in the video?". Once all the steps have been completed, the pre-service teachers gradually arrive at a diagnosis for the vignette they have seen. The process steps served as a structure for working on the video vignettes. This approach is intended to make pre-service teachers aware of the otherwise unconscious diagnostic process and sensitize them to important aspects of the diagnostic process. This procedure is repeated with the remaining three video vignettes to practice the diagnostic process further. This can either be led by the lecturer in a plenary session or carried out in groups. Each group can work on one or more video vignettes, depending on the time available. The group work results are recorded using pens and paper from a moderation kit and then presented and discussed in the plenum.

The teaching format can be adapted to suit individual circumstances. Suppose you have less than 90 minutes available for the teaching format. You can provide the video vignettes and the corresponding tasks to the pre-service teachers in advance so that they can work through the content independently (flipped classroom). This eliminates the preparation time for introducing the topic and watching the video vignettes, so you can start discussing the individual vignettes immediately. Further, the difficulty level can be varied via the task. For pre-service teachers, it's easier to make a diagnosis when guided through structured tasks [WM25]. Thus, lecturers can support pre-service teachers in working through the video vignettes by initially structuring the tasks, such as "Describe which aspects of the student's behavior you consider diagnostically relevant in the lesson sequence shown. These aspects relate to the student's content knowledge, problem-solving process, and affective aspects such as motivation and emotion". At a later stage, or in the case of advanced pre-service teachers, this assistance can also be omitted, and a diagnosis for the respective vignette can be requested directly.

## 4 Implementation of the teaching format

We tested the format described above in various forms in our teaching. To this end, the teaching format was embedded in an introductory lecture on computing education. The participants were pre-service teachers at the end of their Bachelor's degree program or the beginning of their Master's degree program in computer science teaching. All pre-service teachers had a solid knowledge of Java programming and had already been introduced to Greenfoot during the lecture.

In the first run, the format was carried out in person with eight pre-service teachers. However, the procedure differed from the one presented here in that the lecturer introduced the process model and its steps before the vignettes and the associated questions were presented. There was no link between the questions and the respective steps of the process model at this point. After revision, the presented concept was tested online with nine pre-service teachers and in person with three pre-service teachers. In the online format, the pre-service teachers worked independently in a learning environment that mirrored the teaching format described. Due to the online format, the only thing missing here was the discussion of the results after each step of the process model. Instead, examples of possible answers were displayed, which the pre-service teachers could compare with their results.

Due to a tight time frame, we planned the final in-person session to be in abbreviated form. The video vignettes and assignments were made available to the pre-service teachers in advance so they could prepare at home (flipped classroom). The pre-service teachers' individual steps' results were then presented and discussed in person. Unfortunately, the pre-service teachers did not work through the materials provided at all or only partially, so it was not possible to carry out the session as planned. Therefore, we implemented the concept presented in Chapter 3 with minor adjustments. First, as intended in the concept, the pre-service teachers reflected on their own experiences with debugging in the classroom and collected typical mistakes made by students when programming and debugging. Then, the concept of diagnosis and why diagnosis is essential in teaching was repeated. Finally, the pre-service teachers processed the first video vignette in a plenary session with the support of the lecturer. All steps were carried out as described in the concept. For the first step, *Recognize*, the pre-service teachers independently collected the situational aspects in plenary and discussed their results. If an important aspect was forgotten, the lecturer added it. The procedure was then repeated for the Assess and Generate steps. Afterwards, the pre-service teachers worked in groups on the remaining video vignettes using the same procedure. They recorded their results using pens and paper from a moderation kit. Afterwards, they presented their results to the lecturer and discussed them. Due to time constraints, they did not complete all four vignettes.

The implementation of the teaching format showed which elements of the concept have worked well. As expected, one helpful element for the pre-service teachers was to break down the diagnostic process into its sub-steps when working on the tasks. By dividing the diagnostic process into individual steps and corresponding tasks, it is easier for pre-service teachers to deal with different aspects of student problems, diagnose, and anticipate possible alternative courses of action (cf. [WM25]). Another helpful element was that the diagnostic tasks were worked on in groups rather than individually. Group work helps pre-service teachers to deal with the respective situation in more detail. The different perspectives of the pre-service teachers complement each other so that significantly more aspects are taken into account when drawing up the diagnosis than is the case individually. As a result, the actual situation and its facets are better grasped, and a more comprehensive diagnosis is usually made. Finally, the lecturer should plan sufficient time for the implementation. Even if the video vignettes themselves are very short, the pre-service teachers need time to deal with the content of the vignette, formulate their hypotheses or assumptions, and then verbalize them. Completing a single vignette can take between 20 and 30 minutes. In particular, sufficient time should be allocated for group discussions so that pre-service teachers have enough time to discuss their ideas and answers to the individual steps. If time is limited, it is advisable to have pre-service teachers prepare the vignettes at home (flipped classroom). The feedback we received from the pre-service teachers on the teaching format of diagnostics during debugging was consistently positive. The pre-service teachers found it helpful that the step-by-step processing of the video vignettes enabled them to consciously work through the complex and usually unconscious process of diagnosing. They reported that they benefited from discussing the video vignettes with each other, allowing them to share different perspectives and broaden their perceptions. Individual pre-service teachers also reported that engaging in the discussion was easier if they had already worked with the video vignettes at home.

## 5 Summary and Outlook

Our practical report presented a teaching format designed to help prospective computer science teachers improve their diagnostic skills using video vignettes. In the long term, we intend to make the teaching format available as an online course for other interested educators. To this end, we are currently developing a version of the teaching format that can be integrated into learning platforms such as Moodle or ILIAS, allowing pre-service teachers to work independently. Once this self-study format has been completed, we will study its effectiveness in improving the diagnostic skills of pre-service teachers.

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