Aalto University

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What makes a computer program difficult to comprehend?

Title of the dissertation	Cognitive Complexity of Comprehending Computer Programs
Contents of the dissertation	In an increasingly digital world, computing education has become popular as many countries adopt computational thinking inspired approaches in elementary and high schools. While it is not entirely established how such approaches will translate to actionable pedagogies, evidence from introductory programming courses in higher education shows these courses suffer from issues such as high drop-out and failure rates. While the reasons for such a state of things are diverse and nuanced, some argue that programming is indeed a unique and challenging concept. In this thesis, we focus on the conceptualization of what makes a program difficult to comprehend and evaluate programs' complexity. Such conceptualization allows us to compare programs written even in different programming languages and paradigms. We developed a theoretical model of program's complexity from learners' perspective, which evaluates the structure of program semantics and the cognitive actions embedded in when comprehending code. Such cognitive actions are extracted from the Rules of Program Behavior, a novel conceptualization developed in this thesis which organizes the rules, or simplified explanations, that educators use to transmit programming instruction. Moreover, since our theoretical model outcomes are strongly affected by the learner's prior knowledge, in this thesis, we present an innovative self-evaluation, instrument inspired by Language education tools, that is easy-to-apply, language-agnostic, and partially validated with a large cohort of students, achieving similar results to validated tests. By developing the necessary tools to define and evaluate programs' cognitive complexity, we could better support educators to design individually tailored tasks that can be embedded in more efficiently designed learning trajectories. Such learning trajectories can also introduce a more diverse set of activities that use a more holistic view of programming, where program comprehension is used in a more integrated and granular way. The Rules of Program behavior are a new and exciting formalization that could help researchers communicate their context and educators to share their good pedagogical practices.
Field of the dissertation	Computer Science Education
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