Theory and Practice in Introductory Programming

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Abstract

In the Computer Science community it is widely acknowledged that learning to program involves learning theory as well as practice. Educational research has however since long had an emphasize on conceptual learning (theory). In Computer Science Education research much attention has been paid to some aspects of the practice, such as learning tools (Valentine, 2004), but little research on the corresponding learning outcome from said tools is reported, or how the practice relates to conceptual learning (Gross and Powers, 2005). My main research interest concerns the role of practice in relation to theory when students learn to program. How does learning of concepts influence students' ability to learn and master the practice, and vice versa, how does students' understanding and learning of the practice influence the process of conceptual learning? My research question is specifically:

How is conceptual learning and practice related in programming education?

The present research builds on findings from two empirical studies with computer science students and aims at discussing and problematizing the complex relation and mutual dependency between theory and practice in programming education, with a focus on novice students. Based on the two studies and related work I argue that the practice is not merely a means to reach the theoretical learning goals, but is part of the learning goals. This implies that the programming knowledge area cannot be fully covered by concepts. The practice as such is knowledge that students are supposed to master, and this knowledge carries meaning to the concepts. Furthermore empirical evidence shows that students often experience the practice as difficult to learn as the theory, and that there exists a mutual and complex dependency of the two in the learning process. One cannot be learned without the other, and any of them can become an obstacle that hinders further learning.

The present work emphasis the importance for researchers and educators to understand both practical and conceptual learning, and how these two are related. The results point to that one of them cannot be fully

researched without the other; both need to be studied simultaneously in order to understand the learning process.

The work furthermore proposes a way to research the connection between conceptual and practical learning. By combining results from a phenomenographic analysis (Marton and Booth, 1997) on novice students' understanding of the concepts *object* and *class* (Eckerdal and Thuné, 2005) with common novice programming activities, it is argued that activities at different levels of proficiency relate to qualitatively different conceptual understandings. Conceptual understanding at a certain level can help to reveal the meaning embedded in corresponding activities, and facilitate for improved practical skills. Similarly, when the meaning embedded in activities at a certain level of proficiency are discerned, this can open a space for learning aspects of concepts at a corresponding level.

The results that emerged from the analyses of the two studies can to some extent explain why e.g. lab activities do not automatically lead to deepened conceptual understanding, and why conceptual understanding do not automatically lead to a higher level of skillfulness in programming education. The former is clearly showed in the history of computer science education, while the senior students in the second study specifically emphasize the latter. Activities that relate to more advanced ways to understand the concepts may not be meaningfully carried out by students who have not reached corresponding level of conceptual understanding, and ways to understand the concepts that go beyond the level of the students' practical proficiency may not be understood or discerned by the students. The present research suggests that in order to make certain practice meaningful and thus open a space for learning, corresponding level of conceptual understanding need to be reached. The reversed order of learning is also possible: if students discern the meaning embedded in a certain activity, this can open up a space for learning the corresponding level of conceptual understanding.

Discussion

The present research discusses that the knowledge area in programming education cannot be fully covered by concepts; the practice per se is part of the learning goals. Furthermore the practice and conceptual learning cannot be separated in the learning process, and practice and theory mutually carry meaning to each other. How can students possibly advance their conceptual understanding and practical skills in such a complex learning space?

Phenomenography has been used in educational research to identify critical features of various phenomena like concepts, and variation theory has been used to discuss patterns of variation to open a space of learning for students (Marton and Booth, 1997; Marton and Tsui, 2004). If practice, and not only theory, is part of the learning goals, and if practice and theory are so inevitably and complexly related in the learning process so that they mutually carry meaning to each other, does this imply that there are educationally critical features of novice students' practice on which patterns of variation can be applied in order to find implications for teaching and learning?

The present research raises some important questions:

- How can phenomenography and variation theory be used for research on students' learning the practice?
- Specifically, are there educationally critical aspects of the practice that can be identified, and on which patterns of variation can be applied?

I aim to present results up to date, but more importantly, I would like to discuss the questions above and other theoretical implications that follows from the results that the knowledge area involves theory as well as practice, and that they are mutually dependent and carry meaning to each other.

References

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