Chapter 4

A Framework for Developing Deeper Self-Directed Learning in Computer Science Education

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ABSTRACT

To prepare students for the challenges of the Fifth Industrial Revolution, it is essential to cultivate deeper self-directed learning (DSDL) in computer science education. The process of DSDL empowers students to take ownership of their learning, enabling them to transfer their knowledge and skills to unfamiliar contexts. The proposed DSDL framework is anchored in cognitive load theory and social constructivism and draws upon three core concepts: the organization of course content; teaching and learning methods rooted in cooperative learning; and the characteristics of tasks. The importance of structuring course content to offer an initial holistic overview of key concepts, followed by deeper cycles of revisiting and reinforcing these concepts is underscored. Teaching and learning methods, such as cooperative pair programming and cooperative pair problem solving, are recommended. Moreover, the framework advocates for the adoption of a whole-task approach, involving authentic, complex tasks that encourage students to grapple with challenges and to learn from their failures.

INTRODUCTION

Computer Science is characterized by change and new technological developments. Disruptive changes that affect various sectors often originate within computer science (Majumdar, Banerji & Chakrabarti, 2018). Students in Computer Science should therefore be lifelong learners and should have a sound knowledge base of information and communications technologies (ICTs). They further need to acquire a multitude of skills, such as problem-solving, computational thinking, and critical thinking. Computer Science educators therefore have the daunting task of facilitating challenging subject content, fostering a multitude of skills, and preparing students for an unknown future.

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Self-directed learning (SDL) is the process during which students take ownership of their learning by identifying their learning needs and applying strategies to address these needs (Knowles, 1975). Research underscores the importance of SDL to address the challenges of a changing world. It is however argued that SDL is not sufficient to address the challenges of the Fourth Industrial Revolution (4IR) (Van Zyl & Mentz, 2022). Even as society and education are trying to address the complexities of the 4IR, Nosta (2023, para. 3) argues, "we are on the cusp of yet another transformative era", namely the Fifth Industrial Revolution (5IR), which is envisioned to be cognitive in nature and characterized by profound change. Consequently, students are now, more than ever, expected to embody the characteristics of lifelong learners, equipped with the competence to transfer knowledge and skills for addressing future challenges in unfamiliar contexts. This necessitates the cultivation of deeper self-directed learning (DSDL) competencies demanding that students identify their learning needs, resourcefully locate, and employ materials and strategies to attain their learning objectives, transfer knowledge and skills to solve novel problems, and evaluate whether successful knowledge transfer occurred (Van Zyl, 2020).

The recognition of the significance of knowledge transfer within educational institutions has grown substantially (Cheng, 2021). Moreover, strategies intended to enhance knowledge transfer must adopt modified perspectives (Van Merriënboer & Kirschner, 2018). Prior activities and misconceptions could influence transfer attempts (Beker, Kim, Van Boekel, van den Broek, & Kendeou, 2019), particularly in Computer Science education (CSE), where even minor misconceptions can yield significant consequences. Students in CSE must grapple with complex tasks where prior knowledge of various interrelated concepts is required.

In this chapter, it is therefore argued that the objective of CSE should revolve around cultivating DSDL. This chapter does not aim to provide specific recommendations on teaching computer programming or delve into the challenges associated with such instruction. Rather, the intention is to underscore the comprehensive nature of CSE, extending beyond mere computer programming, and consequently, accentuating the complexity of CSE. The aim is to propose a conceptual framework for an educational environment within CSE, with the primary objective of fostering DSDL.

The following research question subsequently guides this chapter: Which framework can be proposed to develop DSDL in Computer Science education?

To answer this research question, the following objectives are discussed in this chapter:

- the importance of DSDL in CSE;
- a theoretical framework for developing DSDL based on cognitive load theory (CLT) and social constructivist theory; and
- a framework to promote DSDL in CSE, and which focuses on structuring course content, the role of cooperative learning, and the characteristics of tasks or assignments.

BACKGROUND, CONCEPTUAL AND THEORETICAL FRAMEWORK

This section illuminates the extensive array of knowledge and skills essential to CSE to shed light on the multifaceted nature of the discipline. The significance of developing DSDL in CSE will subsequently be emphasized. To underpin discussions and provide a theoretical foundation for the forthcoming proposal of a DSDL framework, CLT and social constructivist theory will be examined.

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