Computational Thinking in Problem Based Learning – Exploring the Reciprocal Potential

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Abstract. This paper presents the initial insights from a study in which we explored the relation between computational thinking (CT) and problem-based learning in higher education. CT skills are increasingly recognized as a necessity to all lines of study, as they not only facilitate digital proficiency, but potentially also a sense of computational empowerment and an ability to take a critical and constructive approach to applying computers when solving complex problems. The distinct focus on higher education is routed in theoretical as well as empirically based challenges, as this particular group of learners for the vast majority have started their education in a mainly analogue learning setting, yet now face employments with a much stronger demand for digital competences. The discussions presented in this paper takes its point of departure in the Aalborg PBL-model.

Keywords: Problem based learning · Computational Thinking · Learning process recognition · Digital skills · Digital empowerment

1 Introduction

The vast majority of research in CT in educational settings focuses on K12 learners and on STEM oriented educations [1]. While recognizing the value of these studies, we find it necessary to focus equally on the possibilities and limitations of CT in higher education. Firstly, in consideration of the rapidly developing need for digital literacy in the labour market, and the responsibility of higher educations to also consider employability of students once their education is complete. Secondly in recognition of the development in K12 educations, where the focus on CT and digital proficiency at an earlier age will greatly influence the demands of higher education in the future.

Most often, CT is associated with learning designs, which focus particularly on product development, where different learning material and tools are applied in practice with the aim of establishing CT competences [2, 3]. However, if learners are to gain a deeper understanding of CT, exploring and identifying pedagogical frameworks with particular potential to this subject is of equal importance. Steps towards investigating best practices in learning designs for CT have been made in relation to e.g. game based learning [4]. Contributing to this ongoing research, we argue that if CT is to influence

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educational practices at all levels of education, and be of value to learners who do not have a distinct study focus on technical subjects, it is reasonable to also investigate the relation between CT and more generic pedagogical frameworks such as problem based learning (PBL).

2 Computational Thinking in a PBL Context

In essence, CT represents the notion that concepts and perspectives from computer science may be applied in areas such as problem solving and in exploring and describing complex systems. By approaching complex problems with a computational mind-set, complex problems may be reduced into smaller and more manageable problems [5] and as such be solved more efficiently [6]. As such, CT is argued to hold potential in different levels of education and across a broad variety of subjects.

Problem Based Learning (PBL) on the other hand is generally recognized as an exploratory approach to learning, which based on real world problems, enable students to learn through practical experience. Contrary to traditional approaches to higher education with lectures and independent studies, PBL is widely understood as providing an engaging learning environment where different study activities are planned in a manner, which facilitates and inspires the students work as they explore and respond to identified problems [7].

While PBL is internationally recognized and applied, we place a particular focus on the AAU PBL approach. This approach maintains that optimal learning conditions require that the students acquire new skills and insights by actively exploring and testing theories and methods in practice. Moreover, the approach distinguished itself by focusing on prolonged learning processes allowing the students to immerse themselves into their problem solving process [8].

In spite of the recognized potential of the PBL approach and in recognition that the PBL practice is often identified as one of the factors which motivate both Danish and International students to apply to Aalborg university, the approach is not without its challenges. Supervisors and lecturers across different faculties indicate that students often find it challenging to maintain and articulate the value of the project process in comparison to the results of an exam. Experiences show that students at both bachelor and master level have a tendency to refer to their project reports as “the project” leading the PBL process to be recognized as secondary to the documentation process and the grade of the semester [9]. It is with this challenge in mind, that our study aimed at exploring the reciprocal benefits of considering CT in a PBL context in higher education.

2.1 Exploring Theory in Practice

Having explored the relation between CT and PBL from a theoretical perspective, a pilot study which aimed to combine these two fields in practice was conducted at Master level programs in communication and information technology under the faculty of humanities. 20 students from Master.it programs were included in the study. Students were distinctly introduced to CT at two different occasions. First as part of the semester introduction and secondly at the end of the first semester. As such the study

enabled us to benchmark the students' CT skills at the beginning of their studies and again after having completed a PBL process. The data collected at the start of the study revealed that while all students were able to briefly explain what they had done in their bachelor project, few students at the beginning of the semester were able to reflect upon or even consider the individual CT skills. In direct contrast, the data collected at the end of the students first PBL based semester revealed that the students had acquired a much deeper understanding of their problem solving process during their first PBL semester. Distinct competences were richly expressed with reference to CT skills. E.g. specific methods were related to the process of decomposition.

3 Preliminary Findings

3.1 CT Provides a Vocabulary for Problem Analysis and Problem Solving

While CT has the potential to enable students to acquire not only diverse digital competences but also an ability to critically asses the implications of technology both in professional and private settings, the PBL approach to learning has benefit of ensuring that these skills are acquired with direct relation to actual real world problems. It is however crucial that students not only become able to assess, apply and construct new solutions with technologies, but also that they acquire competences which qualify them to articulate their process and discuss which parts can be generalized and transferred to other problems and which steps are related distinctly to the individual problem. One of the distinct benefits of bringing a CT perspective into the PBL practice was identified in the students' development of a much richer vocabulary and ability to articulate their problem solving process.

3.2 CT in Humanities Calls for a Stronger Focus on Problem Analysis Rather than Simply Problem Solving

The conducted studies, both theoretical and empirical, prompts us to further consider the PBL process itself and where in this process the CT perspective might comprise a contribution. CT must be implemented and assessed in consideration of the research field in which it is applied. The PBL approach is comprised by three phases where problem solving is central, however it is particularly in humanities a case that the problem analysis is the essential part of a study. Consequently, it may be necessary to clarify that PBL activities such as group work, lectures and literature studies are of as much value to the problem solving process and that CT skills may also serve a distinct purpose in the problem analysis phase. When considering CT in humanities, future research should include investigating if for instance a conceptual understanding of decomposition can contribute to a more structured identification of a problem, or if the PBL process benefits more from a more spontaneous curiosity amongst project group members.

3.3 CT Calls for Prolonged Learning Designs and Practical Experience

In line with the argument that CT comprises an ability to not only apply technologies but also critically and constructively reflect upon their possibilities and limitations in a given context, we argue that the acquiring of CT competences calls for prolonged use of technologies in educational settings, rather than brief introductions. While other technology related perspectives such as usability may be assessed in shorter periods, the ability to critically assess the potential of a technology calls for a contextual understanding as well as practical experience with the technology. Problems do not magically appear, but rather they are identified as a result of a deeper understanding of a given context. By this, we argue that actual experience is fundamental to acquiring CT skills at is through experience that we become able to not only see the potential of a technology but also identify its limitations.

Based on the above points, we recommend that future studies emphasises prolonged use of technologies in educational settings, in order to ensure that students reach a level of reflections which goes beyond usability and leads to a more critical assessment of technologies. We recommend that CT in educational settings include a particular attention towards the problem analysis phase, partly to ensure that students recognize how and where problems emerge and partly to explore further what role CT skills may play in this part of the process. Finally, we recommend that the relation between CT and PBL is explored further both in theory and in practice, with a particular focus on ensuring that CT skills are made relevant not only in an academic context but also related to real world problems.

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