Chapter 5
Efficiently Prompting Students When Developing Computational Thinking Skills: The Impact of Students' Response Modality

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ABSTRACT

This study investigates the impact of student response modality on the development of computational thinking skills in educational robotics activities. Students of an elementary school were divided into three study groups ('Control', 'Selecting', and 'Writing') that implemented activities based on the same teacher guidance while prompted to provide responses of different modalities. The purpose was to engage students in the development of computational thinking skills, focusing on the basic skills of abstraction, generalization, algorithm, modularity, and debugging. These skills were evaluated at different phases during the activity, using different modality (selection, written, and oral) assessment tools. The results suggest that (1) prompting and eliciting thoughts in the form of written or selected answers proves to be a beneficial strategy, and (2) the two groups, 'Writing' and 'Selecting', reach the same level of CT skills, which is significantly higher than the level of the control group.

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INTRODUCTION

Educational Robotics (ER) is a constructivist teaching and learning tool which promotes the development of students' computational thinking (CT) and social skills. Through ER activities, students are motivated and guided to solve authentic problems by programming the behaviour of a physical object (the robot) and getting immediate feedback on their proposed solutions. Researchers argue that ER is a problem-based learning tool which facilitates collaboration, enhances conceptual understanding and critical thinking, and promotes higher-order learning in all scientific fields (e.g. Atmatzidou & Demetriadis, 2016; Atmatzidou, Demetriadis, & Nika, 2018; Eteokleous-Grigoriou & Psomas, 2013; Eteokleous, Neophytou, Kolani & Christodoulou, 2020; Giang, Piatti & Mondada, 2019; Ponticorvo, Rubinacci, Marocco, Truglio, & Miglino, 2020; Sapounidis, Alimisis, 2021; Stewart, 2021). Especially increased is the interest for the contribution of robotics in the development of CT skills, which have been recognized as fundamental for all students. CT, as described by Wing (2011, 2017), "*is the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry out"* and is highly important for controlling and managing cognitive activities in all disciplines (Wing, 2008).

Regarding the guidance provided by the teacher, researchers have focused on the impact that prompting strategies may have on students' effective engagement in the deeper processing of the learning material. Certainly, it is not always clear what type of prompting, and what conditions, can maximize the benefits of this process. Many researchers agree that an effective prompting strategy is providing written answers. However, this type of student response ('writing') is also reported to be tiresome and boring for students, causing heavy workload (Anewalt, 2002; Atmatzidou et al., 2018; Papadopoulos, Demetriadis, Stamelos, & Tsoukalas, 2011).

In the light of above, this study investigates the effectiveness of prompting strategies that trigger students' cognitive processing in ER activities. The focus is on the impact of different students' response modality and the study explores how to achieve improved learning outcomes without the negative impact of imposing on students a heavy workload, as students are not always willing to write down and explicitly report their thoughts during problem solving activity.

Analytically, the study presents the implementation of ER activities conducted with the participation of 56 elementary school students. Students worked in small teams, guided by worksheets to solve authentic complex problems and were guided to develop CT skills based on a CT model that includes: abstraction, generalization, algorithm building, modularity and debugging. The students were distributed in three conditions employing different student response modality as follows: a) *'Control condition'* -the baseline condition teams were prompted during problem solving without being mandatory for them to explicitly answer any of the questions during the activity. b) *'Writing condition'* teams were asked to provide explicitly written answers, in order to describe, document, justify and advocate their suggested solution to the prompts, and c) *'Selecting condition'* teams were asked to select the correct answer in closed-type questions relevant to the type of prompts presented to the other conditions. In the following, we present: a) the theoretical background of our work, and b) a study conducted in an elementary school that focuses on the development of computational thinking skills, and contrasts the impact of three different prompting strategies on response. The results provide encouraging evidence regarding the positive impact on the development of students' computational thinking skills.