A Study on the Assessment of Introductory Computational Thinking via Scratch Programming in Primary Schools

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ABSTRACT

Computational thinking (CT), a transversal intellectual foundation integral to computer science, is making its way into compulsory comprehensive education worldwide. Students are expected to attain skills and knowledge in such interdisciplinary CT principles as Algorithmic thinking, Data representation, and Debugging. Problem-solving by designing and manipulating interactive media with Scratch, a graphical programming tool, is popular especially at the primary school level. However, there has been confusion regarding how introductory CT can be operationalized for educational practice. Teachers and students need research-based knowledge for setting appropriate learning goals in addition to instruments for formative assessment that potentially improve the quality of learning. This study contributes to these issues by developing the assessment for learning of CT via Scratch in primary school settings. A review on prior studies involving the assessment of CT-related computational ideas in Scratch has led to the conceptualization of a revised assessment framework. Next steps in the study are analyzing fourth grade students' (N=58) Scratch projects and exploring complementary methods for analyzing CT in video recordings of the students' programming processes.

KEYWORDS

Computational thinking; graphical programming; Scratch; assessment; primary school; education

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1 PROGRAM CONTEXT

This doctoral thesis is carried out in the Doctoral Programme in Education in the Doctoral School in Education and Psychology at the University of Jyväskylä, Finland. The major subject is Education, and the targeted degree is Doctor of Philosophy (Education). The thesis is an article-based doctoral dissertation, which comprises three articles that will be published in scientific, international, peer-reviewed journals or edited books.

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2 CONTEXT AND MOTIVATION

The computer revolution has resulted in the disciplinary ways of computer science to become ubiquitous in the world. Compulsory comprehensive education is attempting to follow these societal changes by defining curricula that foster CT, a broad intellectual capability, which is expected to support solving a wide range of computational problems in various professional and everyday contexts [6]. Finland is among the front-runners by providing all primary school students with the opportunity to learn the basics of computer programming as per guidelines of the new national primary school core curriculum that came into effect in 2016.

In practice, the curricular reform sets new requirements in terms of, for example, learning material design and the assessment for learning of CT via age-appropriate programming activities. However, the lack of established theoretical models and the scarcity of prior empirical evidence of learning from authentic school environments makes research-based and well-grounded pedagogical decision-making troublesome [5]. There is an urgent pragmatic need to clarify CT contents for the design of learning situations as well as discover appropriate assessment methods that are potentially beneficial for learning in school settings.

3 BACKGROUND RELATED WORK

The key contents in CT have varied across previous literature [5]. A widely recognized line of discourse underlines that its conceptual and practical components comprise interdisciplinary capabilities or competence areas instead of context-specific knowledge in, for example, computer programming. The International Society for Technology in Education (ISTE) and the American Computer Science Teachers Association (CSTA) developed a categorization [1] for transversal CT concepts and capabilities, such as Abstraction and Problem decomposition, for primary and secondary education. Other similar categorizations that define various interdisciplinary CT components and their core characteristics have also surfaced.

Scratch is a free block-based programming environment, which allows the manipulation of interactive media, such as games and animations, with a commitment to the constructionist principles of learning [3]. Among others, students' Scratch projects and their programming processes are complementary entry points in assessing CT in a holistic way [4]. The pedagogical purpose of assessment is to support the process of learning. Especially formative assessment, which establishes "where the learner is going", "where the learner is right now", and "how to get there", is potentially beneficial for supporting learning [2]. As programming is a demonstration of

CT and an activity during which students can receive supports for their learning processes [5], authentic programming activities are potentially fruitful platforms for formative assessment in this context.

4 STATEMENT OF THESIS/PROBLEM

The goal of this thesis is to develop the premises of a pedagogically meaningful instrumental system for typifying and assessing introductory CT in Scratch at the primary school level. This goal is addressed in the following ways. Firstly, prior frameworks and instruments for assessing CT-related ideas in Scratch are reviewed for their theoretical and operational capabilities, limitations, and opportunities for formative assessment. Secondly, revised frameworks for assessing CT in students' Scratch projects and their programming processes are designed. These frameworks are designed to conjoin parts to a holistic assessment system that is potentially helpful for improving the quality of learning. The frameworks are used with samples of data comprising students' authentic Scratch projects and video recordings of their programming processes to provide empirical evidence for primary students' CT capabilities.

5 RESEARCH GOALS METHODS

This study employs a literature review and an empirical case study. In the first phase (2017-18), the literature review is conducted for prior peer-reviewed studies concerning the assessment of introductory computational contents in Scratch. The contents are categorized according to the descriptive characteristics assigned for interdisciplinary CT components in seminal background literature (e.g., [1]). Preliminary results suggest that a myriad of computational content that relates in many ways to CT is scattered across multiple prior studies. The review will produce a synthesis comprising fundamental conceptual and practical ideas in CT, their respective operational introductory contents in Scratch, and indications towards assessing said ideas and contents.

The second phase (2018-19) involves the development of a revised framework, the "CT Alphabets" (CT-ABCS), for contextually typifying and assessing the CT indicated by students' Scratch projects. The framework is applied in practice with a sample of data to empirically investigate students' CT capabilities. The participants were fourth grade students (N=58) who attended an introductory Scratch programming course (twelve 45-minute lessons in total). All Scratch projects that the students programmed as groups and returned during the course (339 projects in total) were stored for analysis. The analysis of CT indicated by the projects is currently in progress.

Additionally, eight student groups (1-3 students per group) were video recorded while they programmed their final project assignments: interactive Scratch games or stories (approximately 560 minutes of video in total). The third phase (2019-20) is set to involve an in-depth examination regarding how the analysis of programming processes complements the analysis of Scratch projects.

6 DISSERTATION STATUS

The thesis document has been outlined and drafted. The document comprises an introduction, a theoretical background, a methods section, a summary of results from the three articles in addition to conclusions drawn from the study. The three articles correspond with the three data analysis phases described above. The report of the literature review (phase 1) will shortly be submitted for peer review in a scientific journal.

The development and the application of the CT-ABCS framework has been initiated based on the preliminary results received in the literature review. Currently, the main pursuits are adjusting the conceptual and operational premises of the framework and seeking further content validation for it. The next larger step in the study is exploring prospects for analyzing the students' programming processes alongside their projects.

7 EXPECTED CONTRIBUTIONS

Pragmatically, the thesis is expected to contribute pedagogically meaningful instruments and their conceptual premises for typifying and assessing introductory CT in primary school students' Scratch projects and programming processes. However, considering the advised time for completing the thesis, further testing and validation for the frameworks could be necessary after the case studies. Moreover, a pedagogically convenient instrumentalization of the frameworks (e.g., automatization into a digital learning-support system) for educational practice could be a next step.

The attained empirical evidence regarding fourth grade students' CT capabilities in Scratch is expected to provide valuable knowledge for pedagogical decision-making, such as the appropriate setting of CT-related learning objectives and assessment criteria in addition to indications towards courseware and learning material design.

Moreover, the development process of the assessment system and the developed conceptual notions regarding assessment could possibly be analytically generalized into other learning contexts concerning CT and programming as well (e.g., robotics, digital game-play, text-based programming).

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