WORLD CONFERENCE ON COMPUTERS IN EDUCATION 2017
3-6 JULY 2017 / DUBLIN / IRELAND

Symposium: From Curriculum Visions to Computer Science and Computational Thinking in the Curriculum in Practice

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Introduction

This symposium builds on a series of meetings and symposia at TC3 conferences led by the IFIP TC3 Curriculum Task Force and EDUsummIT 2015. The work originated from concerns across many countries about the need for curriculum change in Computer Science. A report based on this work [1] was presented to IFIP General Congress in 2016. In this symposium we aim to take forward this work by addressing the following questions:

1. How has Computer Science been incorporated into the curriculum in various contexts and what are the rationales for these decisions?
2. What frameworks can support the development and implementation of Computer Science curricula?
3. How can computational thinking, as an important element of Computer Science in practice, but which also has wider application and implication, be developed and consolidated within Computer Science curricula and wider curricula contexts?
4. What is the relationship between computational thinking, digital and other literacies and Computer Science?
5. What are the major issues affecting implementation of new curricula for Computer Science including relationship with other curriculum areas, student motivation, pedagogical approaches?

The outcome of the symposium is expected to be a report further clarifiying issues regarding curriculum design, implementation and associated pedagogical considerations.

Keywords

Computer science · curriculum · computational thinking · pedagogy · digital literacy

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Computer Science in the school curriculum: issues and challenges

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Abstract

This paper will outline findings and recommendations from work of the IFIP TC3 Task Force: "Curriculum-deeper understanding of roles of CS/Informatics" as well as that of EDUsummIT Thematic Working Group 9. The situation of the curriculum for Computer Science varies between countries. In some, e.g. Cyprus, Poland and Israel, Computer Science has existed as a curriculum subject for many years. For others the curriculum for Computer Science has recently been substantially revised after a period of neglect followed by calls for reform. Even in those countries where Computer Science in the curriculum has a long history, there are differences in approach and in the importance of various factors that affect curriculum design and implementation. Our analysis and discussion, based on examination of curriculum change in ten countries, as well as a review and content analysis of curriculum reports, led to a rich range of issues and considerations and a set of questions.

In a report based on this work [1] and an updated version in July 2016 a number of challenges for Computer Science in the school curriculum were identified and recommendations were made to policymakers, practitioners, industry leaders and researchers.

Keywords

Computer science · curriculum · computational thinking · pedagogy · digital literacy

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Austrian Schools on the Way to a Sustainable Basic Digital Education for All.

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Abstract

After nearly 30 years of a non-binding nature of digital coverage in Austrian schools at lower secondary level, the year 2017 seems to mark the transition to accountability in the form of a national curriculum for a new subject called Basic Digital Education. Recently, a curriculum has been developed and will be piloted in some schools within the ministerial initiative eEducation. This curriculum covers all four years of lower secondary education and entails digital-, Informatics- and media competences. It consists of the topics Social Aspects of Media Change and Digitization, Information-, Data- and Media competence, Office Applications, Media design, Digital Communication and Social Media, Security Issues, Technical Problem Solving and Computational Thinking. As all the years before, it is still up to the schools to implement the curriculum in the proposed subject Basic Digital Education and/or within other existing subjects. In order to assure that all pupils will meet the requirements of the curriculum and its intended competences at the end of lower secondary education, there will be a quality assurance check. With this and other accompanying measures, a first important planning step in Austria is done. But the challenges for a veritable success of "Basic Digital Education for All" lie ahead.

Keywords

Curriculum · Competence · Informatics · Digital Literacy · Media Literacy

Timely updates for Computer Science curricula

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Abstract

New computing-style curricula adopted by many countries since 2014 are predicated on the underlying concepts of binary arithmetic and procedural algorithms. Given this recent adoption of computer science for schools, what are the arguments for suggesting changes to the subject?

One powerful argument is the availability from May 2016 of an open accessible quantum computer (IBM, 2016). It provides anyone with an internet connection access to a five-qubit quantum computer, together with training materials, a programming environment and a simulator. Students accessing this resource will encounter a dramatic alternative to binary logic because a qubit can have both horizontal and vertical polarization.

This non-algorithmic, non-binary form of computing is now available and expected to provide significant advantages over more traditional forms. From a curriculum perspective, how urgent is it school students encounter such an alternative? The current availability of a quantum computer makes this a more pressing question, but the dramatic difference from mainstream coding activities would make teachers and curriculum designers reluctant to adopt.

To adapt to this kind of innovation, it would seem prudent for curriculum designers to at least reserve a substantial part of the final year of compulsory schooling in computing for emergent technologies. Teachers will need suitable update materials annually. Such an approach can provide an opportunity for the emergence of new workers in these critical areas, and provide a wider community understanding of their social implications.

Keywords

Computer science · school education · quantum computing · curriculum

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On the Discussion of Mandatory Computing Education: What are the Arguments?

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Abstract

The increasing spread of technology based on digitization has led to a broad and ongoing discussion on the consequences that education must draw. Educational strategies are being discussed around the world, aimed at preparing young people as best as possible for the challenges of the so-called “digital world”. There is a broad agreement that learning with digital media must lead to a transformation of school education, but there is much debate about the importance of computing education for all pupils.

In Germany, a strategy document on education in the digital world was published in 2016 by the National Board of the Federal Ministers for Education. On about 60 pages the document focused on digital media competency and innovation of the education system, but there was no explicit inclusion of a computing subject into an overall conception, although in the drafting process this lack was commented by various actors.

To gain an insight into the worldwide discussion, various documents (scientific papers, political documents, blog entries) were examined by means of a qualitative content analysis according to Mayring for advocating and rejecting arguments for a mandatory computing subject at K12 level. This paper summarizes the research process and results.

Keywords

Computer education · K12 · arguments · mandatory subject · qualitative content analysis

The prioritisation of classroom activity and resources in the teaching of computing: A study into the development of student teachers of computing in England

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Abstract

The computing curriculum in English secondary education is in its third year of implementation and has grown in prevalence and status within English schools. During placements in schools, student teachers have experienced variations of computing subject knowledge of pupils and teachers, availability of resources and curriculum structure [1]. During the last three years, there has been a noticeable shift in delivery and resourcing of computing in schools and student teachers have been able to adapt their practice and priorities as a result. This is a three-year study comparing three different student teacher cohorts and how they have viewed and implemented approaches in the classroom such as group work, physical computing, 'unplugged' activities and programming. Using images as a stimulus, this study has explored student teachers' views and personal priorities in delivering the computing curriculum. The students have developed a visual hierarchy of the images which most represent their values and practice in teaching computing [2]. The use of images has allowed the dialogue to move away from the restrictions of terminology whilst generating self-reflection and debate. The three year comparison shows only minor change in priorities of the student teachers in the pedagogical processes of teaching computing.

Keywords

Computer science · computing · secondary · student teachers · visual research methods

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Implementing computer science curriculum in schools in Poland – issues, challenges, and practice

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Abstract

A new national curriculum for all subjects including computer science (CS) in primary schools K-8 has been approved by the Ministry of National Education in the mid of February 2017, and a new curriculum for secondary schools will be ready in 3-4 months. The new CS curriculum will take effect from September 1, 2017. The general construction and building blocks of the CS curriculum are described in [1].

There are a number of challenges and open questions regarding the implementation of the new CS curriculum in schools. How to motivate and engage students to learn/study/use/develop CS knowledge, skills, and competencies through K-12 is one of the main challenges. As a sample answer to this question we will describe a sequence of consecutive students' activities through 12 years of CS education on topics related to sorting and searching information – such topics are present in almost all CS curricula over the World.

Then we will restrict our attention to the initial education in K-3 stages, when the main focus is on integrating all "educations": literacy, numeracy, informatics (CS), science, arts, technology, and also physical education. We will present a virtual environment for supporting students and teachers in learning and teaching CS integrated with other "educations".

Keywords

Computer science · programming · elementary education

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Technological Pedagogical Content Knowledge as a Framework for Designing Technology-Enhanced Learning Environments for Computer Science: Effects on Student Learning

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Abstract

In this study, the authors directly respond to this call and adopt the framework of Technological Pedagogical Content Knowledge (TPCK) (Angeli & Valanides, 2009), in order to design technology-enhanced lessons for computer science topics, namely: (a) Data, Processing, and Information, (b) Central Processing Unit, and (c) Programming and Algorithmic Thinking. For the first computer science topic, the results showed that students' posttest performance on the concepts "data," "processing," and "information" in the experimental group outperformed students' performance in the control group, $F (1, 348) = 378.04$, $p < 0.01$. For the lesson about the Central Processing Unit, the results also showed statistically significant differences in performances between the experimental and the control groups in favor of the experimental group, $F (1, 259) = 427.76$, $p < 0.01$. Finally, similar results were obtained for the third lesson on the development of algorithmic thinking with significant differences between the experimental and the control groups in favor of the experimental group again, $F (1, 235) = 62.52$, $p < 0.01$. In conclusion, the results of this study showed that TPCK was an effective framework for the teaching of Computer Science topics.

Keywords

Computer science · programming · secondary · education · computing

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Defining procedures in early computing education

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Abstract

From the early years of educational programming Papert and other researchers considered *procedural abstraction*, i.e. defining new procedures, the key instrument of computational thinking, an important approach in "the art of splitting difficulties" [1], and strived to understand its cognitive difficulty. At present, defining procedures is promoted in renewed computing curricula in several countries. For example, Computing at School (CAS) in the UK characterises procedure as a mechanism of abstraction, an instrument of generalisation, a pattern to be used to control complexity by sharing common features [2] and recommends that as well as *using procedures*, pupils should become proficient in *creating new abstractions* of their own. To meet this need, in many recent programming environments for novice programmers it is possible to define new procedures.

And yet, procedural abstraction is rarely acknowledged by more recent educational research. In this paper, we consider the fact that the delayed implementation of a mechanism for building procedures within Scratch, a widely used programming environment for children, may have negatively impacted the focus within curricular content and educational research on this powerful idea.

In our work, which is a part of a broader research project, ScratchMaths [3], aiming to explore connections between developing computational and mathematical thinking in the upper primary age pupils in England, we set out to explore which factors play a role in upper primary pupils understanding and utilizing the concept of defining procedures as a common and inherent instrument of their programming. We present our observations from the project design schools and demonstrate how they guided the development of our *pedagogic strategy for definitions*.

Keywords

programming · primary education · procedure · abstraction · ScratchMaths

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Broadening Participation of Elementary School Teachers and Students through Curriculum Integration and Statewide Collaboration: A U.S. Experience.

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Abstract

This paper explores challenges and lessons learned by EDC, the Massachusetts Department of Elementary and Secondary Education (DESE), and school systems around the state of Massachusetts as they design, develop, and test the integration of computational thinking into mathematics and science curricula in grades 1-6. The paper discusses (1) the US need for increased computer science education, (2) the structural and pedagogical processes being used to incorporate CT into academic disciplines and how these have been designed to facilitate scale-up, (3) the methods used to ensure high quality teaching/learning experiences for both computational thinking and academic disciplines, and (4) the nature and intensity of support needed by teachers to integrate CT. It closes with a set of recommendations for educational leaders and practitioners who are intent on working in their own communities to explore the integration of CT through disciplinary learning.

Keywords

computer science · disciplinary learning · computational thinking · curriculum integration · computing

Student Motivation and Content in CS Course: Less is More

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Abstract

In this contribution we will address the issue of student motivation of implementing new curricula for CS/informatics and how our solution was tested to help improve the students' motivation at the university level.

Our CS introduction to computers a common core for non CS students includes these main topics: computer hardware (system unit, secondary storage and input and output), software (system and applications), database and networking. Then we teach algorithms and programming skills using python. Based on the number of absences, students not following in class and not participating, and students expressing their boredom in the end of the semester survey; we saw that student motivation was an obvious and serious challenge.

The approach is to reduce the content and emphasize on what is taught and see if the students' motivation will improve. After having made the changes we compared the students' grades and collected professors' observations on the students' motivation. Based on those results we found that less is more, students were kept engaged for longer periods of time, and the grades have improved and therefore the students have more motivation for technology related topics and to further explore computer related content outside the classroom.

Keywords

Computer science · CS curricula · student motivation · education ·