Authors:

Cyril Brom[1], Tereza Hannemann[1], Anna Drobná[3], Kristina Volná[2]

[1]Faculty of Mathematics and Physics, Charles University, Prague, Czech Republic

[2]New Media Dramaturgy Center, Czech Television

[3]Faculty of Education, Charles University, Prague, Czech Republic

Title:

Computing-related Pre-conceptions of Primary School Children: Initial Insights from a Pre-study

Abstract

Primary-level computing curricula are being revamped in many countries in order to foster programming skills. However, little attention is given in schools to the topics of how computing devices and the internet work. Little is known about what pre-conceptions primary school children have about basic computing-related concepts, including the data storage and data size, computer code, the internet, and computer viruses and antiviruses. Almost nothing is known about which of these pre-conceptions are resistant to change; i.e., what concepts are difficult to understand and what concepts are easy. As part of a larger project on creation of an educational, animated series for children on how computers work, we have started to map these pre-conceptions among 2-5-graders and examine difficulty in acquiring scientifically normative, age-appropriate understanding of the respective concepts. As the first step, we explored this issue in an informal way in 27 classes in the Czech Republic. So far, we have got the following initial insights: a) there is a large degree of heterogeneity in levels of understanding among children; b) children's understanding is often incomplete and fragmented; c) a recurring misconception is that Internet is located on the child's device, and this misconception is resistant to change; d) some children have no notion of data size, but this notion appears to be teachable easily; e) the ideas that computers do not have brain and programs are controlled by a program code appear to be easily graspable. This proposal includes discussion of our theoretical underpinnings and the next steps.

Introduction

Present-day primary school children are regular users of computing devices and the internet. Age-appropriate understanding of how these technologies work is crucial for them; however, children are rarely taught the needed concepts in schools (e.g. The Royal Society, 2017). Little is known about what pre-conceptions about these technologies children have. The field of primary computing education focuses primarily on fostering programming skills, but much less so on computing-related pre-conceptions (see e.g. Diethelm et al., 2012; Robertson et al., 2017 for rare examples). Also from the perspective of conceptual change research field, these pre-conceptions have rarely been examined.

At the primary education level, the topic 'how computing technologies work' includes the following concepts (e.g., CSTA, 2017):

- data storage and data size;
- a computer network and the internet;
- computer code, software errors and software updates;
- computer viruses and antiviruses.

Knowing what pre-conceptions children have about these topics is important, because these pre-conceptions present context within which further knowledge can be constructed (e.g., Duit et al., 2012). Plus, some of these pre-conceptions may be resistant to change, but information about which computing-related pre-conceptions complicate learning is lacking.

We have collaborated with Czech Television on developing an animated, educational series in order to teach, among others, the concepts above. The series' protagonists can magically enter the world inside a computer, depicted using the metaphor of a city (Fig. 1). The city is a structural model of the insides of a computer and the internet. Within this project, we have also prepared model school lessons. As part of doing so, we have run a pre-study to get initial insight into the following issues:

1. Do primary school children have *any* pre-conceptions concerning the topics above?
2. If so, is there a large degree of heterogeneity in levels of understanding among children?
3. What are examples of recurring pre-conceptions?
4. What misconceptions appear to be resistant to change?

Method

We visited 27 2nd to 5th grade classes (age 8 – 12) in 7 public schools in the Czech Republic. Generally, these children were not previously exposed to computing topics in schools.

The primary purpose of our visits was to prepare the model school lessons (using design-based research method). So far, we have created four school lessons. Each lesson typically includes:

- an introduction (~5-10 min);
- projecting an episode from the series (~5 min);
- commenting what happened and asking questions, while showing portions of the episode again; describing key concepts using child-intelligible analogies (e.g., "a YouTube video travels across the internet like a large dinosaur's skeleton dismantled into boxes when the skeleton is moved from one museum to another museum") (~10 – 15 min);
- supplementary tasks without computers (~5 – 10 min);
- a conclusion (~5-10 min).

A lecturer from the research team worked with intact classes (~20-30 children). We did not collect data from individual children: the purpose was to obtain initial information (across each class).

In the introduction, we probed what pre-conceptions children have about the respective topics. For instance, the lecturer asked a question (e.g., "Can a computer feel sad?" or "What is larger: a video or a text document?") and the children raised (or did not) hands while (typically) having their eyes closed. The lecturer asked similar questions also later in order to obtain feedback on children's progress in understanding. Feedback was also obtained based on how well children completed the assigned tasks. An independent observer made notes on the lesson and quality of children's answers.

Results

Tentative results suggest that:

a) there is a large degree of heterogeneity in levels of understanding among children ranging from none to 'child expert' level; most often, understanding is incomplete and fragmented; the levels of understanding are not necessarily related to age; between-classes heterogeneity is large (which cannot be explained by levels of formal computing-related training);

b) a recurring misconception is that the internet (YouTube especially) is, in some way, located on the child's device, and this misconception appears to be resistant to change;

c) the youngest children have no notion of data size, but this notion appears to be teachable easily;

d) the idea that computer does not have brain/emotions and programs are controlled by a program code appears to be easily graspable;

e) children know little about computer viruses and antiviruses (see Hannemann et al., 2019; Tsarava et al., 2020 for details).

Discussion and Future Plans

We have presented initial insights into computing-related preconceptions among 8-12-year-olds and into levels of difficulty in teaching the respective concepts. To our knowledge, this is the first work that has done so (as concerns these topics). The obvious limitation is that our research method precludes going beyond initial insights; however, this was a pre-study only. During the round table discussion, we would like to discuss a) our next step: running interviews with individual children, mapping pre-conceptions in more detail; b) theoretical framing of the research. As concerns the latter point, we consider to frame our results within diSessa's 'knowledge-as-elements' conceptual change model (1996). In our opinion, it can capture well the fragmented understanding of children concerning these concepts. However, we are open to any suggestions from the audience.

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