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Researching and Developing Pedagogies Using Unplugged and Computational Thinking Approaches for Teaching Computing in the Schools

How to Teach Computing Without Computers?

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KEY IMPLICATIONS

- Unplugged activities can be enacted by computer teachers to engage their students in the learning of computing concepts and programming.
- Doing an unplugged activity leads students to develop certain cognitive understanding which can assist or influence the way in which they learn, write and test the relevant computer programmes subsequently.
- Teachers appreciate the value and nature of unplugged pedagogies, and some of them can design their own unplugged activities.

BACKGROUND

Teaching Computational Thinking (CT) and Programming requires a pedagogy that would be different than conventional approaches such as inquiry or direct instruction. Teaching computing unplugged (without the use of computers) has gained momentum in countries such as New Zealand and United Kingdom where teachers and students learn computing concepts through fun kinesthetic approaches (see efforts like CS Unplugged of the University of Canterbury at http://csunplugged.org). Removed from the possible distraction of using computers, participants can focus and discuss on the fundamental concepts of computing. For example, students can act out the how items are sorted by different sorting algorithms and make comparisons. Through acting, and visually looking and comparing how items are sorted, they can create a mental model of the different algorithms to discuss their effectiveness.

Unplugged activities are designed to engage students in the thinking and understanding of computing concepts but teachers may still be challenged on how these activities can be integrated into day-to-day classroom lessons and how can they assess their students learning on computing concepts.

We are interested in activities and pedagogies that move students forward from unplugged to crucial computational experiences in general (Grover & Pea, 2015), and more specifically, in our context, relevant to the computing syllabus in Singapore.

FOCUS OF STUDY

The main focus of this research study is to develop and evaluate pedagogies linked to teaching CT. We introduce teaching unplugged as an effective student-centered approach to introducing computing concepts without the use

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of computers, and then we design follow-up activities and pedagogies that move students forward in the crucial computational experiences.

The study also seeks to assess the effect on students and teachers. Students' work will be analysed to assess their level of comprehension and application of computing concepts, and this will be done through prior experience surveys, pre-post computing perceptions survey, pre-post computing tests, quizzes and computing assignments. Teachers' pedagogical content knowledge will be assessed to understand the level they started with, and the level they would have attained after the workshops and teaching in class. Classroom observations will be held to study the teachers' enactment of computing lessons. We want to understand the territory of teachers' dispositions for, attitudes toward and stereotypes concerning CT and Computing.

KEY FINDINGS

There is a range of unplugged activities which can be introduced as part of computing lessons to firstly, engage and motivate students, and secondly, with good teacher facilitation, help students develop appropriate mental models or what is called notional machines of computing concepts and algorithms. New activities can be designed by teachers that fit well with the computing curriculum. When students engage in these activities, they develop computational skills such as decomposition, pattern recognition, abstraction and algorithmic thinking.

SIGNIFICANCE OF FINDINGS

The following are some of the outcomes of this study:

- Lesson plans for selected unplugged methods available to all O-level Computing teachers.
- Sharing of unplugged pedagogies to O-level Computing Curriculum Planning Development Division (CPDD)-facilitated Networked Learning Community (NLC) in March 2018.
- Sharing of unplugged pedagogies to A-level teachers in May 2018.
- Sharing with NIE graduating teachers (NIE's Beginning Teachers' Orientation Programme [BTOP]) in Nov 2017, May 2018, Nov 2018, and May 2019.
- Symposium at Redesigning Pedagogy International Conference (RPC) in June 2017.

Implications for practice

In terms of implications for practice, unplugged pedagogies add to the repertoire of teaching methods used by teachers to engage students cognitively in the computing tasks. Here is our list of design principles for incorporating unplugged activities into the computing classroom:

- Identify the learning objectives and communicate this to the students at some point during the lesson. It does not need to be at the very beginning if you have a better hook to grab the students' interest.
- If you need the activity to replace a lesson in your syllabus, make sure that the unplugged activity's learning objectives align with the lesson being replaced.
- Find the appropriate place in your curriculum. For the learning objectives that are more focused on CT (e.g., Algorithm Design or Program Development) and less on specific content (e.g., Computer Architecture, Logic Gates), you can use a variety of unplugged activities.
- Find connections with other topics / concepts / skills in the curriculum.
- Refer back to the unplugged activity later on in your teaching. Unplugged activities are memorable because of their hands-on nature and focus on concrete representations. Take advantage of this to help students recall and build upon what they learned.
- If there are no assessments in the activity, create them.
- Design the lesson to be student centered. Don't let it become a lecture. Unplugged activities are by definition social and hands-on, using concrete materials (moving to abstract representation should happen, but do not push this too quickly).
- Stretch the activity so that it's appropriately challenging for your students. The original unplugged activities were designed to be accessible by a wide range of school age kids (and adults). You may need to design additional worksheets or harder problem sets. One way to stretch is to look for opportunities for students to engage in CT (e.g., design an algorithm using flowchart, pseudocode, computer language; look for a pattern to generalize; build higher levels of abstraction). Another way to stretch the activity is to look for interesting applications in the real world or how the knowledge or skill they gained can be used to solve other problems.

- The updated unplugged activities website has some good examples of CT connections for each of its activities. You can view the binary unplugged lesson here: https://csunplugged.org/en/topics/binary-numbers/unit-plan/how-binary-digits-work/

Implications for policy and research

In terms of implications for policy and research, that some of CT can be taught by unplugged pedagogies suggests that we can reach out to a bigger base of students without the distractions of getting the resources and infrastructure for computer programming.

In terms of earning gains (for studies involving intervention), we published a paper on students doing the unplugged sorting algorithm. Students learning an algorithm like sorting using an unplugged approach demonstrate the learning of computational thinking skills that are beyond students learning the algorithm using a more conventional approach (Looi et al, 2018).

Proposed follow-up activities

In terms of follow-up activities, more workshops and courses to introduce unplugged pedagogies to computing teachers; increase the uptake of these pedagogies. In March 2019, an in-service course on unplugged pedagogies was offered at AST for computing and computer science teachers by the research team, and the course was favourably received.

PARTICIPANTS

Four secondary schools, eight teachers and 130 students are involved in the study.

RESEARCH DESIGN

The research methodology is design-based research (Brown, 1992) using mixed methods to gather and study information on how teachers teach the learning activities, and how and what students learn. The research objectives stated above imply the central theme of the methodology to result in greater understanding of a learning ecology by designing its elements and by anticipating how these elements function together to support learning. The research methods include: survey/questionnaires; interviews; achievement tests; classroom observations; video recordings; teaching/learning artefacts; document analysis.

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