Raspberry Pi

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Semantic waves: analysing the effectiveness of computing activities

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Background and context

Computer science is being introduced at school level worldwide, but with little existing research into appropriate pedagogy, and with many teachers having little experience to build on. Different teaching approaches have emerged with differing degrees of success. Simple ways are needed to help teachers predict the effectiveness of activities and identify ways to improve them.

Research focus

The notion of 'semantic waves' forms part of Legitimation Code Theory, an educational theory by Maton (2013) that has been successfully applied in many disciplines. Its focus on changes in the context-dependence (semantic gravity) and complexity (semantic density) of knowledge offers a good way to think about what makes an effective learning experience. Its utility in understanding the teaching of computing has been argued for by Curzon et al. (2018), Curzon (2019), Waite et al. (2019), Curzon and Grover (to appear). The theory gives a way to think about why different teaching approaches work or do not. It can be used to evaluate individual or sequences of lesson plans, online resources, and to teach students how to write good explanations. To date it has only been applied to one computing activity (Waite et al., 2019) — we provide further evidence of its applicability in computing contexts.

Method

We applied semantic wave analysis to two activities / approaches. The first unplugged programming activity, 'box variables' (Curzon, 2014) was chosen as it was known to be very effective (from student feedback and peer review). The second activity followed the copy-code style (easy for novice teachers), but suggested to be an ineffective way to teach programming. For each activity, the combined changes in semantic gravity and semantic density (concrete, everyday concepts in everyday language versus abstract concepts in technical language) were plotted in a simple, coarse-grained way.

Findings

The profile of the box variables activity was found to follow a semantic wave of moves up and down in context-dependence and complexity, supporting the packing and unpacking of subconcepts. The theory predicts this to be a strong approach. However, analysis highlighted that the repacking section was weak and suggested an improvement of having the students summarise the points learned. By contrast, the copy-code activity had a stepped 'down escalator' unlinked structure, with no unpacking and unpacking support. The theory suggests this lack of linking and repacking would be a critical factor in its lack of effectiveness.

A workshop was delivered to in-service teachers, explaining the theory and having the attendees draw the semantic waves for the activities before discussing them. Attendees were able to draw semantic waves, and doing so led to a discussion about how the copy-code activity could be improved. Participant feedback was very positive about the approach (though this remains informal as yet).

Conclusion and implications

Semantic waves provide a powerful way to think about the effectiveness of a learning activity as well as its particular delivery, and so improve teaching. By looking at changes in semantic density and semantic gravity of an activity, the structure of the activity can be improved. The analysis helps explain how and why unplugged activities can be an effective form of teaching computing, and why ways to teach programming adopting a copy-code strategy may be ineffective. The analysis also suggests how to improve such approaches. This leads one from copy-code activity to code-predicting type approaches, such as PRIMM (Sentance & Waite, 2017), for example.

We believe the theory and analysis techniques behind semantic waves should become a standard part of teacher training for computing teachers both for initial teacher training and as part of continuing professional development.

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