K-5 Teachers’ Uses of Levels of Abstraction Focusing on Design

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ABSTRACT
Recent research with middle school and university students highlights two factors that contribute to programming success: 1) understanding the level of abstraction that you are working at, and 2) being able to move between levels. In this qualitative study, we explored levels of abstraction, and particularly the design level, with five K-5 teachers. Here we outline 11 main findings. The teachers interviewed use the design level for both programming and writing. However, the two expert computing teachers have a far greater depth of understanding of the opportunities for the use of the design level, supporting pupils to understand the level they are working at and helping them move between levels of abstraction by using designs in novel ways. Further work is needed to investigate whether our results are generalisable. Further exploration of levels of abstraction and particularly how the design level helps K-5 learners learn to program, in the same way that planning supports novices learning to write, is warranted.

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1 INTRODUCTION
Despite a lack of consensus on exactly what computational thinking is, proponents of computational thinking, surveys of computational thinking, and emerging curriculum frameworks propose that abstraction forms a core component [5, 10, 15] with ambitious potential and possibly exaggerated claims [12]. We investigate K-5 teachers use of abstraction through the lens of one scenario of abstraction: that of the levels of abstraction hierarchy, particularly focusing on the design level.

2 RELATED WORK
Perrenet, Groote and Kassenbrood [8] proposed a levels of abstraction hierarchy explaining university students’ thinking about algorithms. Armoni [1] suggested a framework for its use and to support understanding renamed the object level the algorithm level. Statter & Armoni [11] reported promising findings on using the hierarchy in middle school programming. In earlier work [14] we aligned the hierarchy with the work of others and renamed the object level to the design level to support K-5 teachers understanding naming the levels: problem, design, code and running the code.

3 AIMS AND APPROACH
Our aim was to better understand the opportunities for use of the levels of abstraction hierarchy, particularly the design level, with K-5 teachers. Using semi-structured interviews augmented with unplugged activities we conducted in-depth interviews with five K-5 teachers. A thematic qualitative data analysis approach was used to analyse the transcriptions [6].

4 FINDINGS & DISCUSSION
We outline eleven of our most interesting findings. These are loosely grouped by Magnusson, Krajcik & Borko’s PCK elements [7].

Goals & Objectives: Use of terms: Our five teachers used a variety of conflicting terms for design, algorithm and code, and had a limited vocabulary to describe running the code. The terms algorithm and code, used as labels for different levels of abstraction, were used interchangeably. Progression is aligned to learners building understanding based on precise vocabulary [2, 9]. Teachers understanding of levels of abstraction may be limited and pupils’ progression in programming may be being compromised by a lack of teachers’ shared understanding. Level of detail: Both novice and expert teachers mentioned the level of detail included, or omitted, by pupils at the design level in literacy and in programming. One expert teacher explained that he demonstrated to pupils how to include ‘less detail’ in computing design than might be expected in plans for other subjects. Teachers’ understanding of the amount of detail needed for each level may impact on teaching and learning of levels of abstraction. Familiarity with and using different design types: All teachers showed familiarity, confidence and a depth of understanding on the use of the design level in a variety of subjects, such as Maths, Music and History. Teachers cited storyboards as being good for sequencing, and concept maps being flexible to add new ideas.
were also used for differentiation and to provide a record of what was to be done, what had been done and what to do next. Annotations not only transitioned the levels of abstraction, but self-assessment of their confidence to implement its components. Self-assessment: Do-ability: The expert teachers required pupils to consider ‘do-ability’. ‘Do-ability’ is understanding whether one can, at one’s current and anticipated level of experience and within the time frame of a project, implement a design, within the constraints of the programming language being used. Self-assessment: The expert teachers required pupils to mark their design with a self-assessment of their confidence to implement its components. Both these assessment activities straddle the design and code level.

5 CONCLUSIONS

Despite a limited population of participants, our findings suggest that the levels of abstraction hierarchy may be useful for reviewing pedagogy for programming. Our novice and expert teachers situate work at the design level in programming as well as in other subjects. Our expert teachers use design in novel and interesting ways including using it to facilitate movement across the levels of abstraction. However, our findings require further investigation to assess whether they are generalisable. We suggest there is particular merit in investigating the use of design as a self-regulation tool to develop independence for novice and struggling programmers in the same way that planning is used to support novice and struggling writers.

6 FURTHER WORK

We plan to explore in more detail the relationship between abstraction, design and levels of abstraction. Our next steps also include: further literature review and survey of experts; a review of curricula material for incorporation of design and other levels of abstraction; a survey of teachers to verify the findings presented here with a wider audience; work with a focus group of teachers to create guidance on the practical application of the levels of abstraction particularly the design level, in K-5 programming teaching.

REFERENCES