An Investigation of Student Learning in Computing Education Research

Jude Nzemeke
judenzemeke@yahoo.co.uk

Literature Review

The offering and delivery of computer science has evolved over the years in the United Kingdom and the response of different institutions has been mixed. When The Rt Hon Michael Gove who was Education secretary in 2013, announced that "harmful" ICT curriculum will be replaced with a more rigorous computer science in schools [Department of Education 2013], a lot of schools were not prepared for this change. They felt the government had not put careful consideration into the challenges of retraining staff to give them the confidence to deliver a new curriculum. Since most schools lacked the expertise to deliver the computer science curriculum, they stopped offering it to pupils as an option. There has recently been a resurgence in the take up of the subject in schools especially with its inclusion as part of English Baccalaureate however, most schools still face challenges with delivery due to lack of expertise [Brown et al 2014].

The impact of this resurgence has been felt in universities in the United Kingdom with 129,610 students opting to study computer science in the year 2021 – a 68.63% increase when compared with the total of 76,860 applicants in 2012. We have more women who have applied to attend university in 2021 (58.93% of applicants) than men (41.07% of applicants). However, further analysis of the data shows that fewer women opt to study computer science at university – 17.52% (22,710 applicants) when compared with men – 82.48% (106,900 applicants) [UCAS 2021].

How should computer science be taught?

A number of professionals and institutions have done research on different teaching pedagogies. Amongst these are the Gradual Release of Responsibility model by Pearson and Gallagher (1983) and the Fisher and Frey model (2013). These models allow teachers demonstrate new skills first and allows learning to gradually progress to the stage where students can independently complete tasks.

The Semantic Waves model, which is an adaptation of the Pedagogical Content Knowledge by Shulman in 1986, expands on the idea and describes processes that means that computer science teachers who are subject specialists should differ their approach when teaching pupils in lessons from when conversing with fellow subject specialists [Maton 2013]. These models allow teachers to use effective metacognitive processes in the delivery of their lessons however, there is a need for further research on the impact of these paradigms in the delivery of computer science in schools [Curzon et al 2020].

Research Focus

- Computational Thinking (CT): CT is a life skill that can be applied not just in the field of computing but also in everyday tasks. However, it is sometimes the case that teachers use programming tasks to conceptualize CT whereas, a holistic approach in using CT when completing tasks may be more effective. Although elements of CT including abstraction, decomposition, thinking ahead and visualisation are included in the curriculum as individual units, the challenge is how often students apply these methods when solving problems [Steinmayr et al. 2019].
- The role/purpose of visualisation learning in computer science: The British Council in an

article on visualisation described it as involving the creation of real or unreal images in the mind's eye. Teachers can use visualisation to model information in ways that allow students understand new concepts better. There is an opportunity in this research to explore how computer science teachers use visualisation and how effective it is in aiding pupils with memory recall [McDaniel and Einstein 1986].

- Relationships between students' wider characteristics (e.g. ability, motivation): it will be easy to think that students who are motivated and those with ability should excel academically. It is however vital that these hypothesis are tested and evidence based.
- Misconceptions, understandings and misunderstandings of core CS concepts from CS1 through to CS3: a number of factors lead to general misconceptions in CS – these include how challenging a task is, students problem solving skills and the competence of teachers [Qian and Lehman 2017].

Research Questions

With the key focus above in mind, I have been able to deduce the following research questions:

- To what extent do students use CT techniques to understand new concepts better?
- How well/often do students use computational methods when solving problems? For example, if faced with a complex programming task, are they able to decompose it first before they start solving it?
- How do computer science teachers use visualisation and how effective it is in aiding pupils with memory recall.
- Do teachers use visualisation to create a vibrant atmosphere in classrooms that encourage learning to take place?
- Do students do well in computing because of their ability to grasp new content or think logically?
- Does the teaching style of particular teachers influence how students perceive their understanding of content and their motivation?
- Does feedback matter, what role does it play in the learning journey of students?
- Do CS teachers and students identify misconception?
- To what extent does misconceptions impact upon learning – if left unclarified?
- What impact does it have on the wellbeing of staff and pupils?

Proposed Methodology

I intend to use both qualitative and quantitative methods in gathering data for the research. Other methodologies I would use include interviews with staff and students, lesson observations, expert opinions, working with focus groups and literature reviews.

I anticipate my research will require the use of "big data". I intend to use data analysis software to interpret and clean up collated data. Software will also be used to incorporate visualisation in the presentation of information and to show relations that may exist between datasets.

I will explore the use of what I will call a "Three Box Model" when teaching students. The idea here is to get teachers to compartmentalize new concepts when teaching and allow pupils to do the same, when solving problems – see table 1 and table 2 below.

Box 1		Box 2		Box 3
Introduce concept	↔	Demonstrate key skills [Complete task together with students]	↔	Students complete task independently
Check understanding		Check understanding		Check understanding

Table 1: Proposed Three Box Model for Teachers when teaching

Box 1		Box 2		Box 3
Read the task		Break task into solvable chunks.		Solve each chunk independently
Ask questions if any part of task is unclear	↔	Seek help if any chunk is too challenging	↔	Bring each chunk together.

Table 2: Proposed Three Box Model for Students when completing task

Scope of research and outreach

I will like to widen the scope of my research to include students in KS5, CS1 to CS3 in England and possibly Northern Ireland. I hope to throw more light on different teaching pedagogies that students are exposed to at these stages and test the hypothesis of the Three Box Model. It would also mean that findings from my research would inform educators and learning institutions on best practices for delivery of computer science across the spectrum.

Why I wish to pursue this research

I am interested in this research as it embodies everything I have aimed to achieve in my teaching career. Having observed general computing misconceptions of KS2 pupils who join my school, in 2013, I sought to bridge the gap between the delivery of computer science in primary schools and secondary. I decided to visit five local primary schools in my free periods to run programming sessions with their staff and pupils for an hour every week – free of charge. Nine years later, over 4,700 students and 351 staff in my local community and across the country have benefited directly from my sessions. Due to my efforts, my school was awarded a “Lead School” status in the delivery of computer science by Computing at School.

I lead a very successful department and I am always seeking ways to improve upon my lesson delivery. My headteacher and other senior colleagues have consistently ranked my teaching as outstanding. Parents have written to my headteacher to appreciate the length I go to support pupils.

As a member of Digital School House and National Centre for Computing Education – institutions with established contact with computing Lead Schools, I meet regularly with colleagues in these groups to discuss teaching pedagogies, research and best practices.

The findings from my research will have a greater impact on how computer science teachers deliver their lessons and how pupils learn. It will be another way I can give back to the community.

Proposed Timeline for completing the Thesis

It is my intention to complete the thesis within four or five years – see figure 1 below.

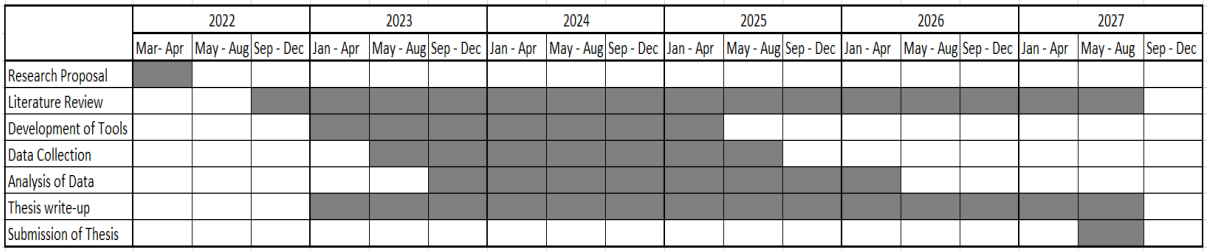

Figure 1: Draft Research Timeline

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