REGISTERED REPORT RESEARCH REPLICATION STUDY

An Empirical Replication of "Computing in the curriculum: Challenges and strategies from a teacher's perspective"

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ABSTRACT
Background: There have been rapid changes to Computing education across all four nations of the UK over the past ten years. In 2014, Sentance and Csizmadia investigated teachers' perceptions of the compulsory inclusion of Computing into the new national curriculum in England using a large-scale survey. The results of this national case study have been widely-cited in the literature, categorising approaches taken by Computing teachers to support students. However, while Sentance and Csizmadia's 2017 paper provides valuable insight into teachers' perceptions from 2014, the data collected was largely from England. Therefore, it did not account for the devolved educational policy contexts across the UK, and the policy and practice changes in the interim.

Objective: The proposed project replicates the original study to find out both how perceptions have changed between 2014 and the present day, and to see how they may be further impacted by diverging UK Computing education policy and practice contexts. Furthermore, the replication will also include specific questions relating to the COVID-19 pandemic in order to better understand its impact on Computing education, and to control for any changes to learning, teaching and assessment that have taken place due to the pandemic.

Method: We propose an empirical replication of Sentance and Csizmadia's 2017 original study, using the same online survey. Both quantitative and qualitative data will be collected in order to better understand the changes in teachers' perceptions toward Computing education, and identify any differences across the four nations of the UK.

KEYWORDS
Computer science education; in-service teacher education; computing curricula; registered report; replication study

1. Introduction

In this Stage 1 Registered Report, we outline our proposal for the empirical replication of Sentance and Csizmadia's highly-cited[1] paper "Computing in the curriculum: Challenges and strategies from a teacher's perspective"[2], published in the Springer journal *Education and Information Technologies* in 2017.

Computing is being introduced into the curricula in many nations, regions and jurisdictions. Teachers' perspectives of these major reforms allow us to discover and better understand what challenges – and opportunities – this presents, and also the strategies teachers claim to be using in teaching the subject across primary and secondary

[1]Citation metrics taken from Google Scholar: `https://scholar.google.com/scholar?cluster=5696382193951950255` (155 citations as of November 2020)

[2]See: `https://doi.org/10.1007/s10639-016-9482-0`

(K-12) education. The study described in this paper was originally carried out in the United Kingdom (UK) in 2014, in the midst of major Information and Communication Technology (ICT) national curriculum reform in England, where teachers were preparing for the mandatory inclusion of Computing into the curriculum. We have since seen major national curriculum reforms published in Wales in January 2020, alongside increased scrutiny of existing curricula in Scotland and Northern Ireland, as well as the quality and perceived value of technical school-leaver qualifications across all four nations.

In 2014, Sentance and Csizmadia launched a survey investigating teachers' perceptions of the compulsory inclusion of Computing into the new national curriculum in England. N=1417 respondents completed the wider survey (1126 of whom were practising teachers), with n=339 teachers contributing at least one free text answer to the free text questions. In the paper, Sentance and Csizmadia primarily focused on the n=339 responses given by this self-selecting group of teachers, but include reference to their other answers to survey questions where relevant. Using Likert-scale questions, they found that the majority of teachers (85%) rated their confidence in being able to deliver the new curriculum at 6 or more out of 10 (Sentance & Csizmadia, 2017). However, this statistic was reported from a subsample of the participants who answered open-ended questions about teaching Computing at school.

Therefore, it is necessary to return to the 2014 data in order to determine the confidence levels within the wider sample of 1,126 practicing teachers contacted through the Computing at School (CAS)[3] UK membership association. Within the qualitative data teachers reported a number of intrinsic and extrinsic challenges in teaching Computing. Statements made by teachers who are currently teaching Computing in school were coded, categorised and analysed, describing both successful strategies for teaching and the difficulties they face. These included the need to change teaching strategy in order to account for the differences between ICT and Computing; concerns over how to teach computational thinking; and, the need to develop resilience in students when learning programming. Overall, the paper offers guidance to teachers on how develop their Computing teaching skills. The results reported in the paper were timely and relevant to teachers and teacher educators in the field of Computing, especially during the midst of major national curriculum reform in England. Their recommendations include the need for further investigation to be carried out around the impact of the strategies suggested in primary and secondary education (Sentance & Csizmadia, 2017). Therefore, the replication of this study would also reinforce contributions to the area of pedagogical content knowledge (PCK) in Computing; PCK is the knowledge that a teacher has about how to teach their subject (Shulman, 1986).

Yet, while Sentance and Csizmadia's 2017 paper provided a valuable insight into UK teachers' perceptions from 2014 (which has garnered significant international attention e.g. Gardiner (2014)), the data collected was largely from England. Therefore, it largely did not account for the devolved educational policy context across the UK, and the policy and practice changes in the interim. Furthermore, while N=1,126 practicing teachers completed the survey, only n=339 completed the qualitative questions on which the findings were based. Sentance and Csizmadia note that the sample they draw upon "may not be 'typical' of the whole teacher population, but represent teachers who are more comfortable teaching Computing" (p. 477). This makes it difficult to generalise the results to the broader population of UK teachers. Therefore, a major justification for an empirical replication of this research study is to explore how

[3] https://www.computingatschool.org.uk/

opinions have changed between 2014 and now, and also to gather a more representative sample of practitioners from across the four nations of the UK in order to better understand the impacts of the differing and evolving policy and professional practice contexts.

Through this empirical replication study, we anticipate a more granular response to the original survey instrument, reflecting the increased differences in Computing education policy and practice, as well as the divergence in national curricula and qualifications across the UK. However, we would anticipate a larger range of positive and negative responses, reflecting the challenges of recruiting, retaining and professionally developing Computing teachers across the UK, potentially developing distinct teacher grouping of "haves" and "have nots" in their confidence and capability to deliver specific curriculum and qualifications. By aiming for a UK-representative survey sample, it would provide an opportunity for comparative thematic analysis between the four nations of the UK, to provide deeper insight that may be portable to other nations and jurisdictions.

Finally, the impact of the COVID-19 pandemic on the wider education system, across all settings, has been profound (UNESCO, 2020), presenting significant challenges for learning, teaching and assessment (LT&A) (Reimer & Schleiche, 2020). Across the UK, there have been major responses from various governments, organisations and institutions at all levels and settings; from major national policy initiatives to support learners and maintain quality and standards across all settings, to ongoing government inquiries on the longer-term impact of COVID-19 on education and children's services. Thus, we are keen to better understand the short and medium-term impact of COVID-19 on Computing educators at all levels and settings in the UK, given some of the specific disciplinary challenges of teaching Computing, building on recent work in this space (Crick, Knight, Watermeyer, & Goodall, 2020; Watermeyer, Crick, Knight, & Goodall, 2020), as well as the opportunities for wider education system change (Zhao, 2020); for example, the future of formal examinations and qualifications in the UK.

A Note on Terminology

While in many instances throughout this paper we will refer to the UK – consisting of the four nations of England, Scotland, Wales and Northern Ireland – we will attempt to be as clear as possible when referring to specific policies or initiatives across or between the nations, as a number of policy areas, including education and skills, are devolved to the respective national governments.

With regards to the consistent naming of the discipline through this paper, "Computing" is used as the subject name throughout this paper as well as in Sentance and Csizmadia (2017); it refers mainly to the computer science elements of the curriculum, and is also often referred to as Informatics in other countries.

2. Brief Literature Review

In addition to the review of the key literature in Sentance and Csizmadia (2017), including the theoretical framing, much has developed in a policy and practice context for Computing education across the UK.

Computing has been introduced as a new subject in compulsory-level school curricula in many countries, with broad social, cultural and economic objectives (Tuomi,

Multisilta, Saarikoski, & Suominen, 2018). This brings with it both excitement and challenges, as for any new subject; for teachers facing curriculum change, how to confidently teach it is very pertinent. Introducing new content does not merely mean that teachers have to equip themselves with new subject knowledge, which of course in many cases they do (Brown et al., 2013; Sentance, Dorling, & McNicol, 2013; Sentance & Humphreys, 2017; Thompson & Bell, 2013). Teachers also need to learn appropriate pedagogies for delivering a new subject, particularly in those aspects of computer science that relate to algorithms, programming and the development of computational thinking skills (Davenport, Hayes, Hourizi, & Crick, 2016; Kong, Lai, & Sun, 2020; Murphy, Crick, & Davenport, 2017).

The UK has seen rapid change – in both curricula and qualifications – in the area of computer science education in recent years, across all four nations of the UK (Brown et al., 2013; Brown, Sentance, Crick, & Humphreys, 2014; Cutts, Robertson, Donaldson, & O'Donnell, 2017; Moller & Crick, 2018), with education being a devolved responsibility for the individual governments, parliaments and assemblies. Before the major national curriculum reforms from September 2014, many schools and teachers in England had implemented elements of the new Computing curriculum prior to the official starting date of the Computing Programme of Study (Department for Education, 2013) in September 2014, as a void was left by the disapplication of the existing curriculum subject, ICT, in January 2012 (Brown et al., 2014). We have also seen major curriculum reforms in Wales, published in January 2020, with substantial shifts from ICT to Computing, the recognition of statutory cross-curricular digital competencies, and the development of a new Science & Technology area of learning and experience (Welsh Government, 2020). Alongside these curricula reforms, we have also seen significant changes to the available technical school-leaver qualifications, taken at the ages of 16 and 18.

Recent literature relating to Computing education in school highlights a number of ways of making computer science concepts accessible, engaging and fun, and more importantly, giving students a deep understanding of these concepts. This should be grounded in appropriate educational theory and methods, directly supporting effective professional practice. Thus, the implementation of a new Computing curriculum involves a change to teachers' practice (Moller & Crick, 2018; Sentance & Humphreys, 2017; Thompson & Bell, 2013) across both their subject knowledge and pedagogical knowledge. With respect to the introduction of technology in classrooms, a different context, it can be seen that there is an intersection between teachers' knowledge, beliefs and culture (Ertmer & Ottenbreit-Leftwich, 2010; Voogt & McKenney, 2017) and this may indeed be the same for Computing. This further draws on the work of Finger and Houguet (2009) who, also working in the area of adoption of technology into the curriculum, describe a range of intrinsic and extrinsic challenges that teachers face in moving from the intended to the implemented curriculum (van den Akker, 2004; Vinnervik, 2020).

Prior to the work of Sentance and Csizmadia (2017), Black et al. (2013) carried out a study in the UK where they asked Computing teachers how they felt they could make the subject interesting. The key aspects that they identified were the importance to teachers of making Computing fun and relevant. In carrying out this replication study, we are interested to see whether the teachers' comments aligned with both the Black et al. and Sentance and Csizmadia studies; we thus wish to further validate actual strategies that teachers use in their classroom that they feel to be most effective for teaching Computing.

In a similar way to the Black et al. (2013) study, this replication study of Sen-

tance and Csizmadia (2017) will focus purely on the teacher's perspective in addressing these important questions. Diethelm, Hubwieser, and Klaus (2012) emphasise the importance of the teacher's perspective to our understanding of computer science education as the teacher "may work on many different abstraction levels or apply very different teaching methods for the same topic of the curriculum" (p. 167), which is reaffirmed by later work (Bender et al., 2015; Hubbard, 2018). We wish to identify what these methods are, in particular identifying common themes that may help to provide guidance for teachers new to teaching the subject, as well as providing actual examples of teachers using effective strategies as we enter a phase of education where more and more students are studying Computing in school, across all four nations of the UK, with significant opportunities to shape evolving Computing education policy and practice.

3. Methods

We propose an empirical replication of the original study from Sentance and Csizmadia (2017). We have secured access from the authors to the original survey, and both the quantitative and qualitative data to be able to provide comparative analysis to the 2014 results.

Further to the two research questions outlined in Sentance and Csizmadia (2017):

- *What pedagogical strategies do teachers report work well for teaching computer science in school?*
- *What challenges do teachers report that they face?*

We propose the following three additional research questions as part of this empirical replication study:

- How have teachers' perceptions of Computing in the curriculum changed between 2014 and 2021?
- How do teachers' perceptions of Computing in the curriculum differ by UK country?
- Has COVID-19 had an impact on teachers' perceptions and confidence teaching Computing?

3.1. Sample

Replicating the original study, this research will use an online survey targeting the UK membership of the Computing at School (CAS) UK network, as well as convenience sampling through social media platforms such as Twitter and LinkedIn. Furthermore, in order to ensure a representative sample from across the UK, CAS-related networks to CAS will be used in Wales, Scotland and Northern Ireland through professional contacts and policy links.

3.2. Survey

The data will be collected using the Qualtrics online survey software. The survey will follow the same structure as was used in Sentance and Csizmadia (2017), therefore it will collect demographic questions, followed by the same Likert and open-ended

questions. Furthermore, in order to address the research question on whether there has been an impact of COVID-19 on teaching Computing, the survey will contain questions specifically relating to whether the rapid transition to online learning, teaching and assessment has impacted teacher confidence in teaching Computing.

3.3. Original survey

The data from the original Sentance and Csizmadia (2017) survey will be used in order to determine whether there are significant differences between the original 2014 data, and the new survey data. Both quantitative and qualitative data has been provided by the original authors in order to undertake this analysis.

4. Plan of Analyses

4.1. Quantitative analysis

In order to understand whether there is a significant difference between the original data from 2014 and the current survey, bivariate time 1 to time 2 analysis will be conducted. The data for this analysis will be weighted post-hoc to ensure that the demographics mirror the demographics of the original survey. T-tests will be used to determine differences in how the amount of time teaching Computing has changed since Sentance and Csizmadia originally collected the data. Chi-square tests (χ^2) will be used to see if there is a significant difference between the confidence levels of teachers between time 1 and time 2.

Secondly, to determine differences between countries of the UK, χ^2 tests will be used to compare confidence levels. χ^2 tests will determine whether educators in each country are significantly more or less likely to state that they are confident teaching Computing.

Finally, to understand the impact of COVID-19 on teacher confidence, univariate and bivariate χ^2 analysis will be used to present the results of the COVID-19 specific questions and to understand whether there was significant difference in responses based on respondent demographic and country.

For all quantitative analysis significance will be indicated by a p value < 0.05.

4.2. Qualitative Analysis

In the original study, the following open-ended survey questions were used to gather qualitative data from practitioners on Computing in the curriculum:

(1) *What good techniques/strategies have you found for helping students to understand programming?*
(2) *Please describe any good techniques/strategies you use for helping students to understand other aspects of Computing?*
(3) *What difficulties, if any, have you experienced teaching programming?*
(4) *What difficulties, if any, have you experienced teaching other aspects of Computing?*

Using a similar method to Sentance and Csizmadia, the qualitative data will be coded and placed into themes. However, rather than using a bottom-up method of

coding, original themes from Sentance and Csizmadia (2017) will be identified in the data. Where an entry does not fit the original code, a new code will be generated. This will allow for comparisons between the 2014 and 2021 data. The data will be coded twice and inter-rater reliability using the Kappa statistic will be performed.

5. Risks

This project has already received ethics approval through Swansea University's Faculty of Social Sciences and Humanities ethics board (approval reference: *SU-Ethics-Staff-151120/295*). No funding is being sought for this research, and there is no dependence on employing additional researchers to complete this proposed replication.

One identified risk to the proposed replication study is related to the current environment in which the data will be collected, due to the ongoing COVID-19 context. It is possible that compulsory (school-level) education may again return to online learning, teaching and assessment due to the continued impact of COVID-19, and that the approach may differ across the four nations of the UK (Crick et al., 2020; Watermeyer et al., 2020). These different educational environment contexts may impact the responses to the questions; however, it is anticipated that by asking specific additional questions about the impact of COVID-19 that this effect can be identified in the in the analysis and be controlled for.

Finally, we intend to obtain a UK-representative sample for this replication study, but this may not be possible due to the chosen sampling methods and prevailing COVID-related factors. Furthermore, we will again recruit teachers through the CAS UK network, who already have access to a lively and supportive grass-roots community of teachers with whom they can exchange ideas and classroom resources. To mitigate this, we will also attempt to recruit participants outside of the (predominantly English) CAS membership, using similar professional networks in Scotland, Wales and Northern Ireland, as well as using convenience sample via social media (for example, Twitter and LinkedIn).

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