Designing to Support Parental Involvement in Computer Science Education: An Exploratory Study

A Thesis Submitted in Fulfilment of the Requirements for the Award of Doctor of Philosophy

2023

Nina Bresnihan

Declaration

I declare that this thesis has not been submitted as an exercise for a degree at this or any other university and it is entirely my own work except where it explicitly acknowledges the unpublished and/or published work of others.

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Summary

This research is situated in the field of Parental Involvement (PI) in Computer Science (CS) Education. While the importance of PI in children’s education is well-established, most parents have little experience in CS and struggle to facilitate the learning of a child in the area. If PI in CS Education is to happen, parents need support. An extensive review of the literature found no studies directly exploring the factors that affect parental engagement in CS Education. It is argued that the identification of these factors is crucial to discerning the level and form of assistance parents require in order to better support their children in their CS Education and should be integral to the design of initiatives to address issues of PI.

This research aims to address this problem area by identifying factors that have an impact on parental attitudes towards PI in CS Education and developing a corresponding research instrument to measure these factors. It further builds on this by developing a set of Design Principles for interventions targeting these factors in order to have an impact on PI in CS Education. It evaluates these by developing model workshops that conform with the principles and exploring the impact of participation in such activities. In pursuit of these research aims, two primary research questions were identified. Namely ‘What factors have an impact on parental attitudes towards PI in CS Education?’ (RQ1) and ‘What principles should inform the design of interventions to support PI in CS Education?’ (RQ2).

Underpinned by a pragmatic research philosophy, a mixed-methods research methodology was employed using elements of a Design-Based Research (DBR) approach. Relevant factors situated in the context of parental computing behaviours and attitudes in the family setting were identified using a literature review, with face validity being provided by an expert focus group. The factors that emerged included computing usage, availability, confidence and experience. In order to confirm these as factors, a survey instrument was developed and completed by a large sample of parents (n=1228). Results of exploratory and confirmatory factor analysis confirmed that the instrument measures five constructs, namely ‘confidence’ measuring parental confidence levels with computing, ‘attitude to PI’, and ‘motivation for PI’, and two types of ‘usage’: ‘creation’ and ‘consumption’. Results of Pearson’s correlation revealed significant positive relationships between confidence and both positive attitudes towards, and motivation for, PI, with linear regressions confirming that confidence was a significant predictor of both.
Regression analysis also identified that creative usage was a predictor of positive attitudes to PI, and that programming experience was a predictor of attitude to, and motivation for, PI.

The understanding of the predictors of PI attitudes and motivation gleaned from the survey, along with a literature review to identify appropriate pedagogy, informed the development of Design Principles for interventions to support PI in CS Education. The principles were used in the development of family creative coding workshops which were iteratively implemented and evaluated as Design Experiments. CPD workshops to train facilitators were also evaluated to further enrich understanding. As well as serving to triangulate and further develop the findings of the survey, the workshop evaluation was employed to further revise and refine the Design Principles. Data analysis looked at whether the interventions effectively implement the identified draft Design Principles, if this had an impact on the predictor factors identified by the survey and did this in turn have any impact on PI attitudes and/or PI behaviour?

The findings of the Design Experiments suggest that activities designed in line with the Design Principles developed in this research have the potential to increase parental involvement and confidence in PI in CS Education, thus addressing some of the issues identified in the analysis of the literature. In addition the survey instrument developed has potential both as a tool for gathering data to discern the level and form of assistance parents require in order to better support their children in their CS Education and as an evaluation tool of such supports.

The main contributions of this research are:

- the identification of factors relating to parental attitudes towards PI in CS Education;
- the development and validation of a corresponding research instrument to measure these factors.
- the development of Design Principles for interventions targeting these factors in order to have an impact on PI in CS Education;
- the national roll-out of model interventions that conform with these Design Principles and a preliminary investigation into whether participation in such activities has the potential to the quality and quantity of PI in CS Education.
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Conference Presentations

Invited Talks

Commissioned Reports
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<td>BCP</td>
<td>Broadband Connection Points</td>
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<tr>
<td>CESI</td>
<td>Computers in Education Society of Ireland</td>
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<tr>
<td>CFA</td>
<td>Confirmatory factor analysis</td>
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<td>CFI</td>
<td>Comparative fit index</td>
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<tr>
<td>CMIN</td>
<td>Chi-square statistics</td>
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<td>CPD</td>
<td>Continuing professional development</td>
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<td>CRITE</td>
<td>Centre for Research in Information Technology in Education</td>
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<tr>
<td>CS</td>
<td>Computer Science</td>
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<td>CSO</td>
<td>Central Statistics Office</td>
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<td>CT</td>
<td>Computational Thinking</td>
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<td>DBR</td>
<td>Design Based Research</td>
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<td>DC</td>
<td>Design Challenge</td>
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<td>DEIS</td>
<td>Delivering Equality of Opportunity in Schools</td>
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<td>DP</td>
<td>Design Principle</td>
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<tr>
<td>DRCD</td>
<td>Department of Rural &amp; Community Development</td>
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<tr>
<td>EDC</td>
<td>Extensive Digital Competence</td>
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<tr>
<td>EDCL</td>
<td>European Computer Driving License</td>
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<tr>
<td>EFA</td>
<td>Exploratory Factor Analysis</td>
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<tr>
<td>EPSS</td>
<td>Design-Based Research Electronic Performance Support System</td>
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<tr>
<td>ERIC</td>
<td>Education Resources Information Center</td>
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<tr>
<td>GDPR</td>
<td>General Data Protection Regulation</td>
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<tr>
<td>ICT</td>
<td>Information and communications technology</td>
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<td>IS</td>
<td>Information Systems</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>KMO</td>
<td>Kayser-Meyer-Olkin measure</td>
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<td>LFS</td>
<td>Labour Force Survey</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<td>NCCA</td>
<td>National Council for Curriculum and Assessment</td>
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<td>NPC</td>
<td>National Parents Council</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<tr>
<td>PAF</td>
<td>Principal axis factoring</td>
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<td>PI</td>
<td>Parental Involvement</td>
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<td>PICS</td>
<td>Parental Involvement in Computer Science</td>
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<td>RMR</td>
<td>Root-Mean-Square Residual</td>
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<tr>
<td>Abbreviation</td>
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<tr>
<td>RMSEA</td>
<td>Root-Mean-Square Error of Approximation</td>
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<tr>
<td>RQ</td>
<td>Research Question</td>
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<tr>
<td>SCSS</td>
<td>School of Computer Science &amp; Statistics</td>
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<tr>
<td>SFI</td>
<td>Science Foundation Ireland</td>
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<tr>
<td>SPSS</td>
<td>Statistical Package for Social Sciences</td>
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<tr>
<td>STEM</td>
<td>Science, Technology, Engineering and Mathematics</td>
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<td>TLI</td>
<td>Tucker Lewis index</td>
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<td>TTIS</td>
<td>Teacher Technology Integration Survey</td>
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<td>VIF</td>
<td>Variance Inflation Factors</td>
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<td>ZPD</td>
<td>Zone of proximal development</td>
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1. Introduction

1.1 Research Problem

The teaching of Computer Science (CS) at K12 level has increasingly become part of the national educational policy in many countries (Keane & McInerney, 2016). This has been driven by worldwide skill shortages in the technology sector but has also been rationalised by the broader argument of the more general value and applicability of Computational Thinking (CT) (Voogt et al., 2015; Wing, 2006). Internationally, there is a body of evidence that parents highly value CS Education and are interested in supporting and encouraging their children’s engagement with it. Over 90% of US parents want their child to learn more CS in the future with two-thirds thinking that it should be required learning in schools (Wang et al., 2016). In Ireland, two in three parents believe it to be as important as mainstream subjects (Finn, 2014) despite a lack of widespread availability in schools. This desire for CS Education among parents, and their willingness to support it, is also clearly demonstrated by the huge success of informal initiatives such as Coderdojo¹ and Codeclub² with parents accompanying their children as well as forming the bulk of volunteer mentors.

The importance of parental involvement (PI) in education is well established (Borgonovi & Montt, 2012; Desforges & Abouchaar, 2003; Epstein et al., 1997; O’Toole et al., 2019). However, the growth in CS Education has exposed questions over parents’ confidence and competence in engaging in computing with their children (Brahms, 2014; Clarke-Midura et al., 2019; Gutnick et al., 2010; Kong et al., 2019; Roque et al., 2016). Many parents have little experience in computing or technology, and struggle to facilitate the learning experiences of a child who has an interest in CS. Kong et al. (2019) argue for the importance of the parents as feedback providers in CS education. In addition, there is some evidence to suggest that parents can directly influence learning when they choose to engage in coactivity with their children (Brahms, 2014; Roque, 2016; Sadka & Zuckerman, 2017; Takeuchi & Stevens, 2011). Parents’ influence on their children’s educational choices is also crucial (Jodl et al., 2001; Palmer & Cochran, 1988) and 90% of Irish parents agree that their awareness of future career opportunities is an important factor in encouraging the choice of STEM subjects (Accenture, 2013). However 68% reported feeling ‘moderately,’ ‘poorly’ or ‘very poorly’

¹ https://coderdojo.com/
² https://codeclub.org/
informed on STEM career opportunities and industry needs (ibid.). This limits the ability of parents to talk to their children about computing; conversations that can be vital for recruiting youth into CS (Clarke-Midura et al., 2019).

With the growing importance of CS Education at K12 level, it is evident that PI, whether it be helping a younger student with their homework or an older student with career choices, is of growing importance. Clearly there is potential for parents to play a significant role in initiating and supporting interest in CS. What is lacking is support for those who wish to undertake this role but feel they lack confidence, knowledge and skills. There is a strong rationale for supports for parents wishing to guide their children in learning skills essential for educational success as well as giving them a creative outlet for critical thinking and collaborative problem solving. However, empirical research on PI in CS Education has been scarce and questions remain over what form of support parents require in order to improve involvement in their children’s CS Education. Questions arise such as what attitudes and behaviours do such supports need to target in order to maximise the impact on both the quantity and quality of such involvement, and how do we best target these attitudes and behaviours?

1.2 Problem Statement

The literature suggests the potential benefits of, and the need for, PI in CS Education. International studies have shown that parents place a high value on CS Education (McClure et al., 2017) and strongly support the inclusion of CS into the school curriculum (Accenture, 2013; Finn, 2014; Wang et al., 2016). However, there is a concern that the current generation of parents do not have the educational experiences or resources to foster their children’s motivation and learning in the area and need support to do so.

While the issue of PI has been extensively studied, empirical research on PI in CS Education has been scarce and questions remain over what level and type of support parents require in order to improve both the quantity and quality of their involvement. In particular, we do not know (1) what attitudes and behaviours we need to target in order to maximise the impact on both the quantity and quality of such involvement, and (2) how to best target these attitudes and behaviours.
1.3 Research Aims
This research aims to provide an evidence-base for the design of interventions to support PI in CS Education. The focus of the research will be on the identification of parental attitudes and behaviours that have an impact on the quantity and quality of PI in CS Education as well as on the development of a set of Design Principles for interventions targeting these factors.

Following from the problem statement, the research aims can be listed as a number of interconnected goals:

- To identify factors that have an impact on parental attitudes towards PI in CS Education.
- To develop and validate a corresponding research instrument to measure these factors.
- To develop a set of Design Principles for interventions targeting these factors in order to have an impact on PI in CS Education.
- To develop model interventions that conform with these Principles and explore whether participation in such activities has the potential to improve the quality and quantity of PI in CS Education.

1.4 Research Questions
In pursuit of these research aims, two primary research questions have been identified:

*RQ1: What factors have an impact on parental attitudes towards PI in CS Education?*

*RQ2: What principles should inform the design of interventions to support PI in CS Education?*

1.5 Research Methodology and Methods
A mixed-methods methodology utilising elements of a Design Based Research (DBR) approach was determined to be appropriate for this research. The intertwined goals of the research were to develop a conceptual framework that will help us understand and predict the impact of interventions on PI attitudes and behaviours in the domain of CS Education and to establish best practice in the design of such interventions. This aligns well with DBR’s commitment to refining both theory and practice by integrating the development of solutions to practical problems in learning environments with the identification of reusable design principles (Herrington et al., 2007).
However, DBR projects involve multiple iterations of the design and testing of significant interventions (Anderson & Shattuck, 2012) and the long-term and intensive nature of this approach has been identified as incompatible within the temporal scope of a PhD (Anderson & Shattuck, 2012; Herrington et al., 2007). It was therefore necessary to limit the scope of the research undertaken for this dissertation to the exploratory cycle of a larger DBR project.

1.6 Positionality and Reflexivity

Reflexivity can be described as “a continual internal dialogue and critical self-evaluation of a researcher’s positionality as well as active acknowledgement and explicit recognition that this position may affect the research process and outcome” (Berger, 2015, p. 220). It is considered an important strategy for quality control, particularly in qualitative research, and necessitates a careful assessment of the impact of the researcher’s biases, beliefs, and personal experiences. In order to support this process Koch & Harrington (1998) note that the interrogation of these personal beliefs and positions before the data generation phase of the research process is advisable.

A reflection on how positionality may have an impact on this research study identified that the researcher’s motivation for and approach to this study has been particularly influenced by her academic and teaching background, but her role as a parent also needs to be acknowledged as being relevant. This background and its possible effect are discussed in the section below. This is followed by a consideration of the researcher’s role, a consideration which also may have had an impact on the research process and outcomes.

1.6.1 Researcher’s Background

My academic background is interdisciplinary in nature, a BA in English and Legal Science was followed by an MA in English. The focus of my MA research was the postmodern American novel and involved an immersion in postmodernist and poststructuralist critical theory from which I emerged shaken and somewhat cynical, with concerns about the moral and ethical implications of unfettered relativism with its hostility to the Enlightenment notions of knowable truth and a rational basis for concepts such as universal rights. A wish to reconnect with the ‘concrete’ manifested itself in a desire to make something. In pursuit of this, I completed an M.Sc. in Multimedia Systems and worked briefly as an instructional designer before (despite myself) returning to academia as a lecturer in the School of Computer Science and Statistics (SCSS), Trinity College Dublin. In addition, I commenced a PhD, investigating digital art in public spaces and its impact on community, based in the
Department of Electronic Engineering. However, this was interrupted by the arrivals, in quick succession, of my two daughters. I am currently a full-time lecturer in SCSS and co-director of the Centre for Research in IT and Education (CRITE) a collaboration between the School of Education and the School of Computer Science & Statistics.

Conducting research in and across four different academic departments (English, Electronic Engineering, Computer Science and Education) has given me first-hand experience of the differences in training and scientific cultures, as well as varying paradigms or epistemologies, across the different disciplines. If, as Koch & Harrington (1998) contend, the researcher cannot be separated from the ongoing traditions in which he or she is engaged, my engagement in many traditions has given me a clearer view of their constructed nature; I therefore consider them to be useful as tools rather than immutable truths. In other words, if I am a pragmatist by inclination, this has only been reinforced by my interdisciplinary experience and training. It will not come as a surprise that this outlook has had an effect on the research process employed here, particularly the choice of research methods.

As well as being an active researcher, I am an educator who has experience in teaching 20 different modules (over five undergraduate programmes, four M.Sc. programmes and a structured Ph.D. Programme). They have ranged over many disciplines, from technical subjects such as web development through to e-learning principles, critical theory and research methods. I have, in addition, supervised over 50 taught M.Sc. Students across three programmes and well as numerous Final Year Projects. The quantity and variety of my teaching has promoted flexibility and adaptability as well as a further appreciation of the value of my interdisciplinary background. As a new lecturer, like many, I taught the way I had been taught (Oleson & Hora, 2014), using a lecture-heavy, instructor-centred approach. However, my teaching approach has evolved through experience and learning, and now lies in the social-constructivist tradition. I try to direct my activity towards the facilitation of an environment in which student knowledge construction and social mediation can take place, creating learning opportunities through collaborative and active learning approaches. I have experienced the effectiveness of this approach in the 3rd-level classroom, and this almost certainly had an influence of the choice of pedagogy for the interventions described here.

In the context of this study, it is also important to note that I am also a parent and, in fact, it is this role that initially provided the motivation for this study. It may be informative here to give some background details. In 2012 a group of friends, some of whom work in computing, started to gather with their young children around a kitchen table in North Dublin once a
month in order to tinker with technology. They played with Scratch\(^3\) and MakeCode\(^4\), ordered some Raspberry Pis\(^5\) and Makey Makeys\(^6\), and they made stuff. They all enjoyed it so much that they wanted to get others involved so they talked to the children’s school about volunteering to run an after-school session. The school provided the support they needed, posters went up and it was completely over-subscribed. Long waiting lists led them to look for further parent volunteers to help run more sessions. This was when I became involved. The school, seeing how successful the programme was, asked the parents to train the teachers in the use of the various technologies and work with them to integrate them into the curriculum. The teachers started to get the children to create such things as Mathematics games and multiple-choice quizzes for Geography and Irish using Scratch. Within the space of just a few short years, I observed how a group of parents had gone from tinkering with their families on a Sunday afternoon to integrating coding into the curriculum in a school of over 500 students. It seemed that something quite powerful had occurred and that the parents had been central to this. The researcher in me wanted to know more about how that had happened, and this study directly sprang from that desire.

Therefore, when engaging in this research I already had a positive view of the potential of PI not only to have an impact on the parents’ own children, but also on their communities and learning environments. I accept that this hopeful bias heavily informed the research proposal and the aims of the research; I actively wanted to support and encourage parents. However, I believe I approached the question of how best to do that, which is at the core of this research, in a spirit of genuine enquiry.

1.6.2 Role of the Researcher

The research described here was undertaken as part of the OurKidsCode project, a Science Foundation Ireland (SFI) - funded project for which I am the Principal Investigator. The project team included another member of the academic staff and two part-time Research Assistants. The team worked largely collaboratively and it is difficult at times to separate out the various contributions. However, when the work described is not wholly mine, I have flagged this and I have tried at all times to be clear and transparent about my role in the study. The dissertation has integrated some multi-authored/collaborative papers and writings already published by the candidate into the body of the thesis. Where this is done,

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\(^3\) https://scratch.mit.edu/

\(^4\) https://makecode.microbit.org/

\(^5\) https://www.raspberrypi.org/

\(^6\) https://makeymakey.com/
the relevant paper is cited and it is outlined at the beginning of the chapter the exact nature of my contribution.\footnote{As set out in Section 8.2. of TCD’s Guidelines for the Submission of Theses and Dissertations available at \url{https://www.tcd.ie/graduatesudies/assets/pdf/theses-submission-guidelines.pdf}}.

As the leader of the project, I did, of course, desire the participants to have a positive experience. However, I aimed to remain as objective as possible as a researcher and included many measures in the data collection and analysis process to promote ongoing reflexivity and mitigate bias including triangulation, peer review, consultation with stakeholders and colleagues, and the keeping of a research diary (Berger, 2015). These measures, along with their limitations are more fully outlined in Section 3.7.

1.7 Contributions

The main contributions of the research are described in the following sections:

1.7.1 Identification of Factors that have an Impact on PI Attitudes to CS Education

Goodall & Vorhaus’s review of best practice in parental engagement emphasises the importance of “understanding what parents already do with their children and how they are most likely to respond positively to attempts to engage them (further) in their children’s learning” (2011, p. 7). In the case of CS Education, this understanding is currently lacking. By identifying factors that have an impact on PI attitudes to CS Education, this research has the potential to address this. For researchers, a greater understanding of the factors that affect PI in CS Education has the potential to guide future empirical research into the design of PI strategies. For practitioners, it is envisaged that they will be of practical use in the design of initiatives to address issues of PI. The identification of factors is discussed in Chapters 4-6.

1.7.2 Development of Validated Instrument

The research provides a validated instrument to support the design and evaluation of strategies to increase PI in CS Education. The instrument has potential both as a tool for gathering data to discern the level and form of assistance parents require in order to better support their children in their CS Education and as an evaluation tool of such supports. Overall, it can be argued that there is sufficient evidence for the validity and reliability of the developed scales to support the use of the instrument in future research into PI in CS Education. Its potential contribution to evidence-based design should assist practitioners and researchers in providing parents with a positive experience of computing, and children...
with the parental support they need for success in the realm of CS. The development, implementation and validation of this instrument is described in Chapters 5 and 6.

1.7.3 Development of Design Principles
The research provides a set of principles for the use of practitioners and researchers in the design of interventions to support PI in CS Education. These principles are built on established theories of teaching and learning. A literature review was conducted to identify potential principles for interventions that would target the factors identified to have an impact on PI attitudes to CS Education. These were then evaluated and refined through the conducting of Design Experiments, an iterative process of implementation and evaluation of associated learning experiences in natural settings, along with the input of experienced facilitators. The development and evaluation of the Design Principles are discussed in detail in Chapters 7-11.

1.7.4 Development of Workshop Models, Sample Activities and Materials
A number of model family creative-coding workshops have been developed along with a practitioner’s guide to their implementation. One-off workshops with a choice of three activities and an extended four-part programme, both consonant with the emerging Design Principles, have been created and evaluated. Findings indicate that they are pragmatic to implement and have the potential to help increase parental engagement with, and confidence in, CS Education. Thirty-three National Parents Council (NPC)\(^8\) facilitators have been trained to date (2022) in the delivery of the workshop along with 30 others consisting of community workers, CoderDojo mentors, teachers and other educators. The workshops are being rolled out nationally, since 2021, by Trinity College Dublin and the National Parents Council (NPC) with the support of SFI funding and the Department of Rural and Community Development (DRCD). The workshops are described in Chapters 9 and 10.

1.8 Peer Recognition
The contributions of this research have been recognised by the academic publication of its outputs and the awarding of substantial funding. Early work on this research was the subject of two conference presentations (ESAI2019, Scratch Conference Europe 2019), and an invited talk at Coderdojo Coolest Projects (2018). Parts of the research have been published

\(^8\) The National Parents Council (Primary) (https://www.npc.ie/) is the nationwide representative organisation for parents of children in primary and early education in Ireland and is recognised by the Education Act 1998. Membership of the NPC provides parents and Parents’ Committees with access to support systems and training programmes.
in peer-reviewed proceedings of two international conferences (ITSCE19, CSEDU19). A book chapter containing an extended and revised version of the CSEDU Paper was published by Springer in 2020. A journal article was published in ACM Transactions on Computing Education (TOCE) in 2021 and, following from this, the researcher was invited to present the paper as part of the ‘TOCE Highlights’ session at ACM SIGCSE TS 2022. Aspects of the research were also used to inform a report on Computational thinking at Primary Level commissioned by the National Council for Curriculum Assessment (NCCA)\(^9\) in 2018.

The researcher was awarded the following internationally peer-reviewed funding as Principal Investigator to carry out the research:

- **2020-22**: Science Foundation Ireland (SFI) Discover Award, €300,000
- **2018-19**: Science Foundation Ireland (SFI) Discover Award, €50,000
- **2017-18**: Science Foundation Ireland (SFI) Discover Award, €50,000

€15,800 funding from the Department of Rural and Community Development (DRCD) has also been secured for rolling out the workshops to date, with a further €159,300 committed for 2023/24.

### 1.9 Research Timeline

The timeline of the research described in this dissertation is outlined in Figure 1.1 below. It began in 2017 with the preparation and submission of the project proposal and has continued to the present with some disruption and interruption due to Government restrictions imposed during the COVID19 pandemic. The restrictions had a detrimental impact on data collection as in-person workshops planned for 2020 could not take place. It also had an impact on evaluating behaviour changes in participants as (1) normal patterns of behaviour were disrupted and (2) follow-up surveys and interviews were difficult to administer. In addition, like many female researchers, the combination of home-schooling children and switching to working online as a full-time lecturer had a serious impact on the time available for research.

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\(^9\) The NCCA advises the Irish Minister for Education and Skills on national curriculum and assessment for early childhood education, primary and post-primary schools and assessment procedures used in schools and examinations on subjects which are part of the curriculum.
Figure 1.1 Research timeline
1.10 Structure of the Dissertation

Following this Introduction, the body of this dissertation can be broadly divided into 3 parts. As each part builds upon and is directed by the findings of the previous parts, rather than the traditional single literature review at the beginning of the dissertation, each part employs a literature review relevant to its particular focus. The first part includes Chapters 2 and 3 and situates the research by providing background and context as well as an overview of the research design. The second consists of Chapters 4, 5 and 6 and is concerned with RQ1, the identification of factors that have an impact on PI in CS Education. Chapters 7-11 comprise the third part which explores RQ2, looking to establish a set of principles to support the design of interventions to improve PI in CS Education. Subsequent to these parts, the dissertation concludes with a discussion and conclusion in Chapter 12. Some more detail on each individual chapter is available below.

Chapter 2 provides background and context for the research through a review of the literature pertaining to CS Education and Parental Involvement, progressing to a more focused exploration of PI in CS Education including barriers and related work.

Chapter 3 gives an overview of the Research Design. This includes a rationale for the choices of research methods and methodology along with an overview of the data collection and analysis process. Limitations and ethical considerations are also examined.

Chapter 4 begins the process of identifying potential factors that may predict a positive attitude towards and motivation for PI in CS Education by employing a literature review. An expert focus group, used to provide face validity for the literature review findings, is also discussed.

Chapter 5 describes the development, deployment and validation of a survey instrument to measure the factors identified in Chapter 4.

Chapter 6 presents the findings of the survey along with their implications and limitations.

Chapter 7 initiates the exploration of RQ2 and the development of the Design Principles by reviewing the literature to identify appropriate pedagogy and design for interventions to improve PI in CS Education. It concludes with a draft of the principles.

Chapter 8 argues for the importance of context to the research and then analyses the context of the Design Experiments to be used to evaluate and refine the Design Principles. It does this by identifying delivery challenges and by conducting a learner requirements analysis through surveys of the target parent and child participants.
Chapter 9 describes how the Design Principles supported the design of the experiments. It describes the activity model and provides an example of one of the workshop designs.

Chapter 10 describes the implementation and evaluation of the interventions. It begins with the evaluation design and then proceeds to describe three Experiments consisting of the implementation and evaluation of a one-off workshop, a four-part programme, and CPD workshops for the facilitators.

Chapter 11 discusses the findings of the Design Experiments, their limitations and their implications for the Design Principles.

Chapter 12 outlines how the research aims have been addressed and presents the contributions of the research. It proposes future and related research before concluding the dissertation.
2. Background and Context

2.1 Introduction
This Chapter looks to provide an understanding of the broad context in which this research is situated through the description, synthesis and analysis of relevant existing research. Its purpose is to frame the problem area, to generate the parameters of the current research and to support the development of the research questions. It begins with an overview of CS Education at K12 level both internationally and in the Irish context. The concept of Parental Involvement (PI) is then examined, particularly in the context of CS Education. Barriers to PI are investigated and related work in this context is considered.

2.2 Literature Review Process
The literature review was conducted in an iterative fashion. Saunders et al. (2009, p. 60) have likened this to an “upward spiral” in which parameters are defined, keywords are generated based on the Research Questions, the search conducted, literature identified, evaluated and recorded which leads to a refinement of the parameters and the cycle starts again (Figure 2.1).

![Figure 2.1 Literature review process (Saunders et al., 2009, p. 60)](image-url)
The literature search began by establishing the initial search parameters. Books, peer-reviewed journal articles and conference proceedings written in English within the broad parameters of Parental Involvement and CS Education were first considered with an early preference for publications which consisted of or included broad syntheses of the literature. Publications were not excluded based on date, as research into Parental Involvement has a long history.

Keywords were identified beginning with general search terms such as: ‘Parental Involvement’, ‘Computer Science Education’ and synonyms such as ‘Computing Education’. Databases relevant to education and technology were queried. These included ERIC (Education Resources Information Center), ACM Digital Library, IEEE, Science Direct as well as the academic search engine Google Scholar. An evaluation of the located literature led to a narrowing of focus and references to the identified seminal works were used to further narrow the searches through the process of “pearl growing” or searching for articles that themselves cite them (Petticrew & Roberts, 2008). “Snowballing” or the use of the bibliographies of relevant literature to discover further sources was also employed (Ridley, 2012).

Parts of this review are based on sections of previous research publications (Bresnihan et al., 2021; Millwood et al., 2018). While these publications were collaborative, the work presented in this chapter was completed solely by the researcher.

### 2.3 CS Education at K12 Level

In recent years, a worldwide skills shortage in the technology sector has led to a growing recognition of the importance of CS Education at K12 level. This has also been fed by the idea of Computational Thinking (CT) being a valuable 21st-century skill for all, one that can promote higher order skills like problem solving, creative thinking, and logical reasoning (Wing, 2006). Wing’s 2006 call for CT to be added “to every child’s analytical thinking” sparked a groundswell of interest in the notion that the kinds of problem solving used by computer scientists can have broader applications. The concept is not just that understanding how our digital world works is of increasing importance, but also that the study of CS can foster CT skills which can actually be applied to many non-digital spheres and has the potential to be a valuable weapon in our problem-solving arsenal. Indeed, if we look to who many consider to be the father of the field, Seymour Papert, we see an even more fundamental argument for its importance: that “certain uses of very powerful computational
technology and computational ideas can provide children with new possibilities for learning, thinking, and growing emotionally as well as cognitively” (1980, pp. 17–18).

While the early champions of CT argued for its broad applicability, Industry, faced with major technology skills’ gaps and clamouring for more qualified computing graduates, quickly hitched the concept to their lobbying wagon. With major reports in the UK (I. Livingstone & Hope, 2010) and US (Wilson et al., 2010) highlighting the danger to advanced economies of the lack of clear education policies centred around the subject of computing, there has been a flurry of interest on both sides of the Atlantic around its teaching in our schools. Indeed, this resurgence of CS Education has been a worldwide phenomenon with many countries responding by updating or developing new school curricula in computing (Keane & McInerney, 2016). In 2012, Israel introduced a new six-year program covering grades seven through twelve introducing a new CS curriculum for middle schools (ages 12-15) (Zur Bargury et al., 2012). The New Zealand Education Ministry announced in July 2016, that it was formally integrating digital technology across the whole learner pathway by 2018 (Ministry of Education, New Zealand., 2016). In the Netherlands a new updated Informatics Curriculum was implemented in 2019 (Barendsen et al., 2016). From the perspective of an Irish audience, perhaps the most pertinent output of this activity was the introduction of a new computing curriculum in England in 2014 which is compulsory from age 5-16 (U.K. Department for Education (DfE), 2013).

Like many countries, Ireland has looked with interest at international developments; particularly those in England. Ireland has made great efforts to attract many of the top international IT companies such as Google, Microsoft, Intel, Meta, Twitter etc. with many setting up their European headquarters here. In 2016, there were an estimated 82,000 ICT professionals employed with an additional 5.2% unfilled vacancies for computing skills. The central scenario set out in the Expert Group on Future Skills Needs 2019 study projects that the high growth in ICT skills demand will only accelerate in the coming years (Expert Group on Future Skills Needs, 2019).

2.4 CS Education in Ireland

The Irish school system is made up of primary and second-level education. Primary education consists of an eight-year cycle: junior infants, senior infants, and first to sixth classes commencing at age four or five. Pupils normally transfer to second-level education at the age of twelve or thirteen. Second-level is split into a three-year Junior Cycle and a two-
year Senior cycle with an optional ‘Transition Year’ in between. It culminates in the state terminal examination known as the Leaving Certificate. Until recently there has been little in the way of formal provision of CS as a subject in Irish schools. However, recent developments include an optional Junior Cycle Short Course in Coding and the introduction, in September 2018, of Computer Science as a Leaving Certificate subject. This was rolled out on a phased basis starting with a group of 40 schools in September 2018 (Connolly, 2018). Three cohorts have completed the cycle to-date. Despite the disruption caused by COVID-19 restrictions, overall the launch was deemed to be successful (McGarr et al., 2020), and a national roll-out to all schools began in September 2020 and is ongoing. There is, as yet, no formal provision of CS in the national primary curriculum. However, the National Council for Curriculum and Assessment (NCCA) ‘Coding in Primary Schools’ Initiative is currently looking at ways of introducing it and have developed a physical computing and play-based pedagogical approach to coding and computational thinking which was piloted across 25 schools in 2018 and 2019 (NCCA, 2019).

2.5 Parental Involvement in Education

The OECD defines Parental Involvement (PI) as “parents’ active commitment to spend time to assist in the academic and general development of their children” (Borgonovi & Montt, 2012). The role of parents in their children’s education has long been of interest to researchers, educators and policy makers. However, investigating the impact of PI is inevitably complex due to the interaction and influence of many factors and variables. For example, parents’ socio-economic status, cultural background, gender and education levels are all significant (Desforges & Abouchaar, 2003). In addition, Epstein’s influential model emphasises the shared responsibilities of schools, families, and communities (Epstein, 2001) and Hornby & Lafaele identify individual parent and family factors; child factors; parent-teacher factors; and societal factors (Hornby & Lafaele, 2011) as being important.

Despite this complexity, findings consistently provide evidence that PI is strongly associated with higher cognitive and non-cognitive outcomes (Borgonovi & Montt, 2012; Desforges & Abouchaar, 2003; L. Emerson et al., 2012; Goodall & Vorhaus, 2011; Harris & Goodall, 2008). Moreover, there is evidence that specific interventions to improve PI can have a positive effect on reading, writing, and mathematics skills (Epstein et al., 1997; Jordan et al., 2000; Starkey & Klein, 2000); homework completion (Cancio et al., 2004); and behaviour (Kratochwill et al., 2004; Pantin et al., 2003). This is despite the complexities involved in the
design of such interventions, including delivery, uptake and sustainability (Goodall & Vorhaus, 2011). The OECD therefore argue that promoting higher levels of PI may increase student outcomes, and that high-quality PI may help reduce performance differences across socio-economic groups (Borgonovi & Montt, 2012). The importance of this happening at an early stage of children’s schooling in order to maximise its impact is emphasised in Sylva et al.’s review of early childhood literature (2004).

PI is generally categorised as formal or school-based PI, and informal or home-based PI (Borgonovi & Montt, 2012; Harris & Goodall, 2008; Hornby & Blackwell, 2018). School-based PI tends to include structured activities such as attending parent-teacher meetings and volunteering in school. Home-based involvement, in contrast, may be less structured and can be further split into academically-oriented and non-academic (LeFevre & Shaw, 2012). The relative impact of each type of PI is disputed, with Harris & Goodall concluding that parental engagement in children’s learning in the home makes the greatest difference to student achievement: “Most schools are involving parents in school-based activities in a variety of ways but the evidence shows but this has little, if any, impact on subsequent learning and achievement of young people” (2008, p. 277). In contrast, Pomerantz et al. (2007) point to consistently positive associations between school-based PI and student outcomes, but less consistent results about home-based involvement. Borgonovi & Montt (2012) suggest that this may be a symptom of the unstructured nature of home-based involvement which leads to a huge variation in its quality. This leads to a conclusion that any consideration of how to maximise the benefits of home-based PI necessitates a close examination of its nature and quality, or what Pomerantz et al. (2007) characterise as the “how, whom, and why” of parents’ involvement.

2.6 Parental Involvement in CS Education

While there has been extensive research on how family interaction influences children’s learning in traditional academic areas (Rogoff, 2003). We know less about how families contribute to building CS competencies. Research into family computing use has tended to look at broader Information and Communications Technology (ICT) issues and focus on concerns such as internet safety and digital literacy with the attention on parents managing and mediating children’s internet use (Goh, et al., 2015; Livingstone et al., 2015, 2017). While some studies have found a positive relationship between childrens' ICT competences and the support they receive at home (Aesaert et al., 2015; Vekiri, 2010; Vekiri & Chronaki, 2008;
Yuen et al., (2018), computing in the home tends to be viewed as a passive or consuming activity rather than something that is active or creative. In this context, children’s computing use is often perceived as a contentious issue that needs to be carefully regulated and controlled by parents (Chaudron et al., 2015; Hollingworth et al., 2011).

The growth of CS as a subject at K12 level has led to questions over the capacity of parents to support their children’s learning in this area (Kong et al., 2019; Roque et al., 2016; von Wangenheim et al., 2017). Many parents’ own education has left them with little experience in programming or computational thinking with the result that they can experience anxiety, lack of confidence, and gendered assumptions about technology (McClure et al., 2017).

More broadly than that, Hollingworth et al. argue “that parents’ orientation and practices are determined not only by their experiences of education and learning and their access to material resources (technology assets), but also the ways in which parents engage with and become familiar with ICT - or not - in their daily lives” (2011, p. 358). Indeed, DiSalvo et al (2014) found that the issue of PI in informal CS Education goes further than parental technical competence and includes the ability to search for CS Education opportunities and identify appropriate computational learning tools. They therefore struggle to facilitate the learning experiences of a child who has an interest in CS.

Despite this, there is strong evidence that parents are interested in CS Education: Wang et al. (2016) found that 91% of US parents want their children to learn more CS and two-thirds think CS should be required learning in school. This desire for CS Education among parents, and their willingness to support it, is also evident in Ireland. As far back as 2014, in a survey of 1,000 Irish adults, 66% believed it to be as important as mainstream subjects despite its then lack of availability in schools (Finn, 2014). Our more recent investigation found that 95% believed that it should be taught in primary schools (Bresnihan et al., 2019b). Parents are also key to choosing non-formal activities for their children (Crowley & Jacobs, 2002) and their willingness to support CS Education is also clearly demonstrated by the huge success of non-formal coding clubs. The CoderDojo movement10 was founded in Ireland in 2011 and there are currently over 250 Dojos nationally and over 2,000 Dojos with more than 58,000 attendees internationally. Parents are required to accompany any child under 12 and, moreover, they often set up and run the dojos. Code Club11 has over 13,000 clubs and 180,000 attendees internationally and, while these are generally run in schools by teachers,

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10 https://coderdojo.com
11 https://codeclub.org
they are often supported by parent volunteers. Parents’ influence on their children’s educational choices in this area is also crucial; with parental support found to be significantly associated with general “career decidedness and career self-efficacy” (Clarke-Midura et al., 2019; Wang et al., 2015). However, while 73% of Irish parents recognise themselves as the biggest influencers of subject choice, 68% reported feeling ‘moderately,’ ‘poorly’ or ‘very poorly’ informed on STEM career opportunities and industry needs (Accenture, 2013). It is clear that as the formal provision of CS Education at all levels grows, parents’ capacity to support their children will become increasingly important.

2.6.1 Barriers
Perceived barriers to PI in education are categorised by Hornby and Blackwell into “individual parent and family barriers; child factors; parent-teacher factors; and societal factors” (2018, p. 109). Of particular concern here, are parents’ beliefs about PI which fall under parent and family barriers. Important beliefs include parents’ “role construction” or whether they believe that they should be involved in both supporting their child’s learning at home and interacting with schools (Hoover-Dempsey & Sandler, 1997) and parental belief in their ability to influence their child’s educational outcomes.

Role construction is important because it establishes what activities parents will value as important or appropriate in relation to their child’s education. This can be driven by the expectations of the groups to which parents belong such as the family, the school, the workplace but is also influenced by factors such as gender or religion. Lack of confidence in their ability to help their child succeed can stem from parents feeling that they do not have the academic competence to effectively support their child’s learning (Hornby & Lafaele, 2011). This is grounded in parents’ beliefs about their personal capabilities and likely effectiveness within the area. The impact of language barriers on the confidence of parents whose first language is not the language of instruction has also been noted (Hornby & Lafaele, 2011) and, interestingly, DiSalvo et al. (2014) point out that barriers to PI in CS Education can go beyond a lack of technical skills and may also include a lack of CS vocabulary. They point out that it is this vocabulary which allow parents to conduct searches for informal CS learning opportunities and to identify appropriate learning opportunities. Moreover, Barron et al. make the important point that technical competence does not just encompass content knowledge; it is “a form of cultural capital that includes values, beliefs identities, and access to knowledge networks” (2009, p. 350). Despite this, numerous studies have actually shown that a high level of education is not required for PI to be effective (Clark, 2015; Hoover-Dempsey & Sandler, 1997). Wang et al. (2015) advise that parents who are
not in technology fields need to know that they have an impact, and that we need to provide education to engender the confidence to encourage their children to experience computing.

Finally, the belief that the child and school wish them to be involved (through invitations and opportunities for PI) can also influence the level of that involvement. Although Hoover-Dempsey & Sandler’s (1997) extensive review concludes that these opportunities will be limited in their success unless they address the issues of parental role construction and parental sense of efficacy for helping their child.

2.6.2 Recent Interventions/Related Work
The increase in interest and activity around CS Education at K12 level has led to a concomitant increase in research in the area. However, there are very few examples of studies focusing on the involvement of parents and those that do exist tend to be somewhat descriptive in nature. A notable early exception is Project InterActions (Bers, 2007) which brought parents and young children, age 4-7, together in a robotics learning environment. This project showed the potential of such interventions to encourage learning about technology with participants reporting gains in their competence and confidence in technology, although parents who were novices benefitted less than those who had previous technological experience.

MIT’s Family Creative Learning programme (Roque et al., 2016) and Brahms’ (2014) exploration of family participation in a museum-based maker space have also brought families together to explore technology. Family Creative Learning explicitly positions parents as “co-learners” with their children and uses constructionist learning principles to support the creative process (Roque, 2020). Both interventions observed that the careful design of the informal learning environments was key to the adults and children becoming effective learning partners (Brahms, 2014; Roque, 2020). The US program Family Code Night 12(Pearce & Borba, 2017) and Startups for Kids13 in France both organise free workshops to teach families about coding in preparation for careers in CS. Both programs anecdotally report that parents and children find participation enjoyable, and report increased interest in coding after these events.

The Brazilian initiative Computação na Escola designed workshops where children and parents learn physical computing together through pair programming. They reported a positive experience with most participants wanting to learn more about programming after

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12 http://www.familycodenight.org/
13 https://startupforkids.fr
taking part. However they noted that in this scenario typically “the child assumed control by assembling hardware parts and programming, while the parent sat by his/her side observing and reviewing” (von Wangenheim et al., 2017, p. 7). This tendency for parents to assume more passive roles, with the children driving activities has been observed in a number of other studies. Lin and Liu (2012) found that when parents and children engage in pair programming, the child tends to lead the project, whereas the parent assumes a “reviewer” role. Similarly, Govind et al. (2020) found that parents reported engaging as “observers and coaches”, in a ScratchJr Family Day, while children engaged as “planners”.

Indeed, the concern about the capability of parents to engage directly in CS means that even when their participation is encouraged, they are often cast in supporting roles. For example, Clarke-Midura et al. (2019) encouraged child participants of a coding camp to bring their creations home and share them with their families, arguing that building this feature into their curriculum design may have influenced participants’ perceptions of parental support. Kong et al. (2019) have emphasised the importance of parents as feedback providers, stating that their involvement and support are crucial to programming education in schools (Kong et al., 2019).

Despite this, there is some evidence to suggest that parents can directly influence learning when they choose to engage in coactivity with their children (Sadka & Zuckerman, 2017; Takeuchi & Stevens, 2011). In addition, Maruyama (2019a) found attitudes toward and confidence in supporting children at home improved as a result of participation in a parent-children workshop. The potential for learning together as a family has also been recognised by Barron who argues that “[g]iven that families are central sites for learning interactions, working to help expand their opportunities to co-learn may be one of the more important things we can do to fulfil the potential promise of technology as a resource for the greater good” (2009, p. 351).

Overall, these finding point to potential benefits for PI when parents and children engage in collaborative CS activities. The design of the interventions in this related work will be explored in more detail in Section 9.2 to assess their possible contribution to the Design Experiments.
2.7 Discussion
The benefits of PI in children’s education are widely accepted, with PI shown to positively impact both cognitive and non-cognitive outcomes. The increasing importance of CS, both as a school subject and as a career choice, suggests the potential benefits of, and the need for, PI in CS Education. Parents already place a high value on CS Education (McClure et al., 2017) and strongly support its inclusion into the school curriculum (Accenture, 2013; Finn, 2014; Wang et al., 2016) and there is clear potential for parents to play a significant role in initiating and supporting interest in CS. However, parents’ lack of belief about their personal capabilities and likely effectiveness within an area has been shown to be a barrier to this (Hoover-Dempsey & Sandler, 1997; Hornby & Lafaele, 2011) and there is a concern that the current generation of parents do not have the educational experiences or resources to foster their children’s motivation and learning in the area (Clarke-Midura et al., 2019; Kong et al., 2019; Roque et al., 2016).

Research showing that interventions to improve the quality and quantity of PI in other domains can be effective indicates the potential benefits of supports for those who wish to undertake this role but feel they lack confidence, knowledge and skills (Cancio et al., 2004; Epstein et al., 1997; Jordan et al., 2000; Kratochwill et al., 2004; Pantin et al., 2003; Starkey & Klein, 2000). However, the same research also points to the need for the careful consideration of many elements in the design and delivery of any such interventions. While the issue of PI has been extensively studied, empirical research on PI in CS Education is scarce. What related work that was identified suggests that parents are likely to default to somewhat passive roles, such as observing or providing feedback (Clarke-Midura et al., 2019; Govind et al., 2020; Kong et al., 2019; Lin & Liu, 2012; von Wangenheim et al., 2017), and while there is value in this, co-activity – where parents and children collaborate on CS tasks – may be a more effective strategy (Maruyama, 2019b; Sadka & Zuckerman, 2017; Takeuchi & Stevens, 2011). Further consideration of what level and type of support parents require in order to improve both the quantity and quality of their involvement in the CS domain is currently lacking. In particular, we do not know (1) what attitudes and behaviours we need to target in order to maximise the impact on both the quantity and quality of such involvement, and (2) how to best target these attitudes and behaviours. The following chapter outlines the research design adopted in order to address these questions.
Chapter 3. Research Design Overview

3. Research Design Overview

3.1 Introduction
This chapter provides the rationale for, and description of, the methodological approach that was adopted for this research. It begins by clarifying the aims and scope of the research. Next it describes the underlying research philosophy of the study and why mixed-methods was chosen as appropriate methodology to address those aims. Following from this, how that methodology was operationalised using a Design-Based Research (DBR) approach is discussed, including providing definitions and a rationale. An overview of the research methods and the tools and techniques used to collect and analyse the data, are also outlined here. The chapter then outlines the limitations of the chosen methodological approach and the methods utilised and any measures taken to mitigate those. Finally, it explains how any ethical considerations of the study were addressed.

3.2 Research Aims and Scope
The literature suggests that parents require assistance to better support their children in their CS Education. As previously noted, the factors impacting on the nature and quality of PI are complex and operate on many levels. While acknowledging this complexity, the scope of this research is domain specific and focussed on understanding how parents’ computing attitudes and behaviours can impact attitudes to and motivation for PI in CS Education.

Despite the acknowledged importance of parental involvement for children’s learning, an extensive review of the literature found no studies directly exploring the factors that affect parental involvement in CS Education. This research looks to address this by exploring the relationship between parents’ own computing attitudes and behaviours and their attitudes towards PI in CS Education with the aims of:

- identifying factors that have an impact on parental attitudes towards PI in CS Education;
- developing and validating a corresponding research instrument to measure these factors;
- developing a set of Design Principles for interventions targeting these factors in order to have an impact on PI in CS Education;
- developing model interventions that conform with these Principles and exploring whether participation in such activities has the potential to improve the quality and quantity of PI in CS Education.
The following research questions were formulated in order to support these aims:

- **RQ1:** What factors have an impact on parental attitudes towards PI in CS Education?
- **RQ2:** What principles should inform the design of interventions to support PI in CS Education?

The findings aim to guide future empirical research into the design of PI strategies by providing a greater understanding of the factors that affect PI in CS Education. The research also aims to provide a validated instrument to support both the design and evaluation of any such strategies. The Design Principles aim to further support both researchers and practitioners in their provision of effective PI interventions.

### 3.3 Research Philosophy

All research includes assumptions about the nature of reality or being (ontology) and about what constitutes acceptable social knowledge (epistemology). Based on these assumptions, it also takes a position on related philosophical issues, such as objectivity and subjectivity and the role of values, context, and contingency. Such issues are typically discussed by contrasting Positivism, with its belief in reality as external, objective and independent of social actors, with Interpretivism, which sees reality as socially constructed, multiple and subjective. The tension between these competing views, often referred to as the ‘paradigm wars’, underpins what Greene (2008, p. 10) characterises as the “great qualitative-quantitative debate” of the past century. Positivism’s view of reality leads naturally to research directed at identifying and analysing the relationships between selected factors in the observable world and tends therefore to be predominantly quantitative in nature (Cohen et al., 2013). In contrast, the interpretive approach requires that research data should describe “not only the purely objective, publicly observable aspects of human behavior, but also the subjective meaning this behavior has for the human subjects themselves” (Lee, 1991, p. 347). Capturing this subjective meaning generally involves a more qualitative approach to data collection and analysis.

The research aims of this study assume that there is an observable reality within which it is possible to identify behavioural and attitudinal factors that lead to outcomes in that reality. In other words, an underlying positivist view. However, given its subject of enquiry, the research also clearly supports the notion that the creation of knowledge cannot be separated from the social environment in which it is formed, a position which is interpretivist.
in nature. The incommensurability of these two philosophies has been noted by many (e.g. Guba & Lincoln, 1989). However, in recent decades it has been argued that these historical conflicts could be reconcilable through new, emergent paradigms, such as Pragmatism, Scientific Realism, or Transformation-Emancipation (Greene, 2008). Pragmatism, in particular, suggests a “useful middle position” (R. B. Johnson & Onwuegbuzie, 2004, p. 17) for this research, recognising as it does both the existence and importance of the natural world as well as a subjective social and psychological world (Greene, 2008; R. B. Johnson & Onwuegbuzie, 2004; Tashakkori et al., 1998).

Pragmatism contends that the best method to judge ideas is by considering their empirical and practical consequences, with justification for a research approach coming in the form of what Dewey (1991) termed “warranted assertability”. Albeit this focus on the outcomes of an enquiry could be argued to be a mechanism, not so much for resolving the philosophical conflict, but for effectively avoiding it in order to proceed to action. Nevertheless, the pragmatic philosophies of Dewey and Pierce, providing as they do systems of inquiry not founded in absolute claims of truth, provide a viable strategy to explain phenomena and produce change in the world (ibid.). How these consequentialist, actionable assumptions about social knowledge that are advanced in Pragmatism underlie the research practice of this study is discussed in the following section.

3.4 Research Methodology

3.4.1 Mixed Methods Research: Choice and Rationale
Researchers, in particular those working in practical fields such as education and health, have routinely rejected the quantitative-qualitative divide and have been using a diversity of methods in their practice for decades (Datta, 1994; Greene, 2008). This practice, rooted in Pragmatism, has been formalised as mixed methods research and is now accepted as a distinctive and effective methodology in its own right (Creswell, 2014; Onwuegbuzie et al., 2010; Tashakkori et al., 1998). Mixed methods research involves the systematic integration of both quantitative and qualitative data within a single study. Johnson & Onwuegbuzie (2004) identify triangulation, complementarity, initiation, development and expansion as reasons for choosing mixed methods research with Creswell arguing strongly for combining the strengths of qualitative and quantitative data to “provide a better understanding of the research problem than either form of the data alone” (2014, p. 2).
Chapter 3. Research Design Overview

Consistent with Pragmatism’s consequentialism, there is wide agreement in the mixed methods community that methods follow from the inquiry’s questions and purpose (Greene, 2008). For this reason this study’s research questions were interrogated to establish the most suitable methods.

**RQ1: What factors have an impact on parental attitudes towards PI in CS Education?**

*RQ1* aims to identify behavioural and attitudinal factors in the target population that predict their attitudes towards PI in CS Education. This conceptual framework of factors and their relationships looks to have wider applicability beyond the direct participants of the study. This need for generalisability and precision points clearly to the use of quantitative methods. While a predominantly quantitative approach may be appropriate, the question also aims to engage with the complexity of human attitudes and behaviours. This calls for a more in-depth exploration of individual experiences; a strength of qualitative methods (Creswell, 2014). In this case qualitative data could serve Johnson & Onwuegbuzie’s purposes of “triangulation (i.e., seeking convergence and corroboration of results from different methods and designs studying the same phenomenon); [and] complementarity (i.e., seeking elaboration, enhancement, illustration, and clarification of the results from one method with results from the other method)” (2004, p. 22). *RQ1* therefore suggests a QUANT+ qual strategy (Table 3.1).

**RQ2: What principles should inform the design of interventions to support PI in CS Education?**

*RQ2* is designed to build on the findings of *RQ1* and explores how to best use this framework to inform the development of Design Principles for PI interventions; any evaluation of which needs to examine how they work in an authentic context. This is consistent with the study’s pragmatic philosophical underpinning which necessitates both the recognition of the importance of local contexts and of treating changes within these contexts as evidence for the viability of any theory. The importance of context, and the opportunity to explore and refine the conceptual framework generated from the investigation of *RQ1* through practice, suggest a predominantly qualitative approach to this part of the investigation. However, in order to measure impact, it can be useful to employ some quantitative methods. An examination of *RQ2* therefore suggests a QUAL+quant strategy. For *RQ2*, using mixed methods provides an opportunity for triangulation and “to expand the breadth and range of research by using different methods for different inquiry components” (R. B. Johnson & Onwuegbuzie, 2004, p. 22). In addition, for the study as a whole, this approach serves the purpose of development; using the findings from the exploration of *RQ2* to further inform the investigation of *RQ1* (Table 3.1).
Table 3.1 Mixed methods by research question

An overview of this research trajectory and associated methods can be seen in Figure 3.1.

3.4.2 Design-Based Research Strategy: Choice and Rationale

The importance of context to the exploration of the research questions here is clear and leads to the conclusion that traditional research strategies, where the focus is on isolated variables and it is possible to somehow ‘control’ all confounding variables, will lead to an incomplete understanding of their operation in context (Barab & Squire, 2004, p.3; with reference to Brown, 1992). However, naturalistic settings bring with them significant challenges, and methodological rigour can be difficult to maintain (van den Akker et al., 2006) with the result that research in the area of educational design has been sometimes criticised as failing to develop a strong theoretical grounding for its findings (Brown, 1992) or as being “pseudoscientific” in nature (T. Reeves, 2006). In order to address these challenges, a number of different strategies to structure and organise the research were carefully considered.

Case studies are often used for observing and evaluating learning in a naturalistic context. However, Yin (2009) advises that they are most suitable for when the behaviours under investigation cannot be manipulated, with their main research strengths being to describe, compare, and/or explain (Plomp, 2013). The deliberate engineering of the planned
interventions in this study in order to develop or validate theories did not quite fit this method.

In contrast, the iterative nature of Action Research with its cycles of planning, acting, observing and reflecting and the importance of context in its implementation aligns well with some of the research requirements. However, Action Research is practitioner-led (Kuhne & Quigley, 1997), and its heavy reliance on its implementation by that practitioner in a particular context with a focus on action and change within that context means that the generalisability of its findings tends not to be a priority.

Design-Based Research (DBR) is another approach that is often employed in educational research, particularly when context is important (Barab & Squire, 2004). While sharing a lot of the same Pragmatic philosophical and methodological underpinnings as Action Research, it does not just focus on local needs but also looks to advance theory: “to uncover, explore, and confirm theoretical relationships” (Barab & Squire, 2004, p. 5). In addition, as Anderson & Shattuck observe “[t]he focus on the evolution of design principles differentiates DBR from much action research and formative evaluation designs” (2012, p. 17). Bakker & Eerde’s summary of these differences can be viewed in Table 3.2.

<table>
<thead>
<tr>
<th>Commonalities</th>
<th>DBR</th>
<th>Action Research</th>
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<tbody>
<tr>
<td>Open, interventionist, researcher can be participant, reflective cycle process</td>
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<tr>
<th>Differences</th>
<th>DBR</th>
<th>Action Research</th>
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<tbody>
<tr>
<td>Researcher can be observer</td>
<td>Researcher can only be participant</td>
<td></td>
</tr>
<tr>
<td>Design is necessary</td>
<td>Design is possible</td>
<td></td>
</tr>
<tr>
<td>Focus on instructional theory</td>
<td>Focus on action and improvement of a situation</td>
<td></td>
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</tbody>
</table>

Table 3.2 Comparison of Design-Based Research versus Action Research (Bakker & Eerde, 2015)

Proponents of DBR claim that it can potentially bridge the gap between educational practice and theory. In particular it “aims both at developing theories about domain-specific learning and the means that are designed to support that learning” (Bakker & Eerde, 2015). This approach goes beyond merely observing and evaluating learning in a naturalistic context to involve systematically engineering these contexts in a way that allows us to generate, evaluate and refine evidence-based claims about learning. Cobb et al. state:

Prototypically, Design Experiments entail both “engineering” particular forms of learning and systematically studying those forms of learning within the context defined by the means of supporting them. This designed context is subject to test and revision, and the successive iterations that result play a role similar to that of systematic variation in experiment. (2003, p. 9)
DBR then, looks to changes within local contexts as evidence for the viability of a theory. Indeed, one of the defining characteristics of DBR is that it be theory-orientated (Anderson & Shattuck, 2012; Cobb et al., 2003; DiSessa & Cobb, 2004; Plomp, 2013; van den Akker, 1999). However, teasing out what ‘theory’ means in the DBR context, while important for clarifying the scope of the research, can be challenging.

Gravemeijer & Cobb (2006) posit that “domain-specific instruction theory” can be developed through DBR by generalising over local instruction theories both about learning processes and about possible means of supporting those processes. In other words, analyses of interventions should include more general phenomena that can inform design or teaching in other situations. The outputs from these analyses are often in the form of Design Principles (T. Reeves, 2006; van den Akker, 1999; Wademan, 2005).

Van den Akker (2006) argues that for this to happen the design of these interventions should be based on a conceptual framework and upon theoretical propositions, so that the systematic evaluation of consecutive prototypes of the intervention can contribute to building this theory. In order for this to happen, the theory should not only guide the design, but also offer a framework for analysis.

This approach then, also aligns well with the research trajectory, as addressing RQ1 involves systematically developing a conceptual framework that will help us understand and predict the impact of interventions on PI attitudes and behaviours in the domain of CS Education. Then, through the iterative execution, evaluation and refinement of such interventions, obtain research results that develop and validate the framework through the consequences of its use (Messick, 1994). This maps to what Barab & Squire identify as a “critical component” of DBR: “that the design is conceived not just to meet local needs, but to advance a theoretical agenda, to uncover, explore, and confirm theoretical relationships” (2004, p. 5). In addition, RQ2, then looks to provide a domain-specific instructional theory, in the form of Design Principles, informed by this framework.

Within DBR, Plomp (2013) distinguishes between development studies and validation studies. Development Studies generate research-based solutions for complex educational problems. It then uses these to advance our knowledge about the characteristics of the interventions and the design and development processes and often result in the development of Design Principles. Validation studies examine the educational interventions with the aim of developing or validating theories or processes (Table 3.3). McKenney and Reeves (2018) characterise this difference between the two purposes as research on
interventions and research through interventions. As can be seen from Table 3.3 below, while a Development Study potentially addresses RQ2, this study leans more towards using the design and development of interventions as a tool to develop and validate theories rather than as an end in itself, and it can therefore be characterised as a validation study.

<table>
<thead>
<tr>
<th>Type of Study</th>
<th>Research Goal</th>
<th>Twofold yield</th>
<th>Research Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development</td>
<td>Development of intervention.</td>
<td>(i) developing a research-based intervention as solution to complex problem, and (ii) constructing (re-usable) design principles</td>
<td>RQ2: What principles should inform the design of interventions to support PI in CS Education</td>
</tr>
<tr>
<td>studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Validation</td>
<td>Theory development and/or validation.</td>
<td>(i) designing learning environments with the purpose (ii) to develop and validate theories about learning, learning environments, or to validate design principles</td>
<td>RQ1: What factors have an impact on parental attitudes towards PI in CS Education? RQ2: What principles should inform the design of interventions to support PI in CS Education</td>
</tr>
<tr>
<td>studies</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.3 The twofold yield of design research (Plomp, 2013)

It is clear then that DBR’s dual goals of refining both theory and practice could provide an effective way of conducting this research. However, as Anderson & Shattuck (2012) have observed, the necessity of multiple iterations of the interventions results in a significant difficulty in limiting a DBR project to the temporal scope of a Ph.D. study. A solution to this problem was inspired by Puntambekar’s (2018) argument that DBR is best characterised as a trajectory of studies, rather than a specific study or a type of study. Regarding it in this way allows for the balancing of DBR’s intertwined goals of refining the design and testing the theoretical constructs underlying the design. Having a trajectory of studies means that not all questions need to be taken up in a single study. Each study in the trajectory should be based on what she terms “key conjectures about teaching and learning” and each study informs the next. This approach is similar to the “programmatic approach” advocated by Plomp (2013, p. 44) or Andersson & Shattuck’s “multiyear DBR research agenda” (2012, p. 18) that envisage larger DBR projects with space for researchers to undertake and “own” significant pieces of this larger agenda. The legitimacy of this approach is further supported by Anderson & Shattuck’s analysis of the five most cited DBR articles each year from 2001-2011 which found only one of the articles focussed on the final write-up of the research. All were part of a multi-iteration project with 18% reporting the exploratory cycle, 3% the post-cycle, and the rest falling into the space between (Anderson & Shattuck, 2012).
This conceptualisation of DBR allows us to characterise the research undertaken here as the exploratory cycle of a larger DBR project which continues to be underway (as described in Section 12.3 Future Research). From this perspective, the results of this exploratory cycle are intended to produce both practical educational interventions and theory generation including measurable theses that can be further investigated in future cycles of the project.

How exactly DBR provides a structured pathway for conducting this research is described in the following section.

3.4.3 Design-Based Research Process

DBR has a number of features, including the fact that it results in the production of theories on learning and teaching, is interventionist (involving some sort of design), takes place in naturalistic contexts, involves collaboration with stakeholders and is iterative in nature (Cobb et al., 2003; Design-Based Research Collective, 2003; Herrington et al., 2005; Kelly, 2003; van den Akker et al., 2006). In addition to these, Anderson & Shattuck (2012) identify the use of mixed methods for evaluation and the evolution of Design Principles as characteristics of a “quality DBR study”:

Reeves (2000) provides an overview of the DBR Process shown in Figure 3.2 below:

![Figure 3.2 Design Based Research approach (Reeves, 2000)](image)

What this involves in practice is further elaborated by the University of Georgia’s Design-Based Research Electronic Performance Support System (EPSS) (Reeves & Orrill, 2006) into the following “general considerations”:

1. Begin with a meaningful problem
2. Collaborate with practitioners
3. Integrate robust theory about learning and teaching
4. Conduct literature review, needs analysis, etc. to generate research questions
5. Design an Educational Intervention
6. Develop, implement, and revise the design intervention
7. Evaluate the impact of the intervention
8. Iterate the process
9. Report DBR
It is emphasised that these may not occur sequentially, instead they often happen simultaneously or in a different order. Nevertheless, how these considerations guide this research, and how that aligns with the research trajectory presented previously in Figure 3.1, is set out in Figure 3.3 below.

**Identification of factors** which have an impact on PI in CS Education.

<table>
<thead>
<tr>
<th>DBR Consideration</th>
<th>Research Action in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Begin with a meaningful problem</td>
<td>Conduct a literature review to establish problem area.</td>
</tr>
<tr>
<td>Collaborate with practitioners</td>
<td>Conduct focus groups with domain experts.</td>
</tr>
<tr>
<td>Conduct literature review, needs analysis, etc.</td>
<td>Conduct a literature review related to the factors that impact PI in CS Education.</td>
</tr>
</tbody>
</table>

**Confirmation of factors** through the development and application of a survey instrument.

<table>
<thead>
<tr>
<th>DBR Consideration</th>
<th>Research Action in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduct literature review, needs analysis, etc.</td>
<td>Design, develop and implement and validate a survey instrument. Analyse findings.</td>
</tr>
</tbody>
</table>

**RQ1: Factors that have an impact on parental attitudes towards PI in CS Education**

**Development of Draft Design Principles** based on lit review & survey

<table>
<thead>
<tr>
<th>DBR Consideration</th>
<th>Research Action in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrate robust theory about learning and teaching</td>
<td>Conduct a literature review to establish relevant existing theory about learning and teaching. Integrate this with findings from survey to inform conceptual framework.</td>
</tr>
</tbody>
</table>

**Design & Development of Design Experiments** based on the Design Principles

<table>
<thead>
<tr>
<th>DBR Consideration</th>
<th>Research Action in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design an Educational Intervention</td>
<td>Design family workshops based on the initial Design Principles</td>
</tr>
<tr>
<td>Develop, implement, &amp; revise the design intervention</td>
<td>Develop, implement and revise the workshop.</td>
</tr>
</tbody>
</table>

**Iterative Evaluation of Experiments** to refine Design Principles & understanding of the factors.

<table>
<thead>
<tr>
<th>DBR Consideration</th>
<th>Research Action in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaluate the impact of the intervention</td>
<td>Further workshops in similar settings and broader implementation with families and practitioners.</td>
</tr>
<tr>
<td>Iterate the process</td>
<td></td>
</tr>
<tr>
<td>Collaborate with practitioners</td>
<td></td>
</tr>
</tbody>
</table>

**RQ2: Principles that should inform the design of interventions to support PI in CS Education (Design Principles)**
Chapter 3. Research Design Overview

This approach involved the collection and analysis of data at a number of points. An overview of this process is given in the following section with more detail being provided in the relevant chapters.

3.5 Data Collection & Analysis Overview

3.5.1 Data Collection: RQ1

An examination of RQ1 had determined that in order to establish what factors have an impact on parental attitudes towards PI in CS Education generalisability was an important consideration. As surveys are particularly suitable for establishing existing conditions at a particular point in time (descriptive) and/or examining relationships that exist between those conditions (analytic) (Cohen et al., 2013) a survey of a large sample of the target population of parents was chosen. In this case the survey is analytic in nature.

However, as Gable (1994) observes, for a survey to be successful in examining such relationships, it must contain the right questions asked in the right way. To achieve this, it is desirable to have clear hypothesised predictor or explanatory variables that are tested for their influence on the dependent variables. Cohen describes these as confirmatory surveys in which “a model, causal relationship or hypothesis is tested” (2013, p. 207).

In order to address the aims of this research, it was therefore necessary to identify factors that may have an impact on PI attitudes and motivation. In order to identify these hypothesised variables a review of relevant literature was undertaken. The process and outcome of this review is described in Section 4.2. A focus group was then conducted with domain experts to provide face validity for the literature review findings (Section 4.3). Having established potential factors and a causal hypothesis in this way, the literature was again consulted to further conceptualise the factors and identify existing measures that could potentially be modified to fit the concepts to be addressed. The survey was developed using the adapted measures and distributed through various channels, using voluntary response sampling techniques. The findings of the survey were triangulated and complemented by the data collected during the exploration of RQ2 (outlined in the following section). This data collection process is illustrated in Figure 3.4.
3.5.2 Data Collection: RQ2

The exploration of RQ1 provides part of the problem analysis phase of RQ2 by identifying factors that should be targeted by interventions to support PI in CS Education. This, along with a literature review to identify appropriate pedagogical theories and practices, led to the formation of draft Design Principles for such interventions (Chapter 7). The principles, alongside a consideration of the delivery context, were used as a foundation for the design of family creative-coding workshops. This process included a learner-requirements analysis using the existing parent survey data and data from the execution of a survey of child learners (Chapters 0 & 9). The workshops were implemented as Design Experiments along with a complementary Design Experiment focusing on the facilitation of interventions in order to capture practitioners’ input (Chapter 10). Details of the data collection and analysis involved in the evaluation of the Design Experiments are provided in Section 10.2. These iterative cycles of implementation and evaluation informed the refinement of the Design Principles and led to enhancement of the workshop design. In addition, this exploration of RQ2 provided triangulation and complementarity for the consideration of RQ1. This process is illustrated below in Figure 3.5.
3.5.3 Data Analysis Overview

For the analysis of the quantitative data collected in the consideration of RQ1, once the parent survey responses were collected, a cross-validation process was used to identify and then confirm the emerging factors. Identification of the factors emerging from the data was completed using exploratory factor analysis (EFA) on a random sample of the data, with confirmatory factor analysis (CFA) used to confirm the findings on the remaining data. This process is detailed in Chapter 5. Preliminary analysis was conducted on the second sample of the data, which had not been used for EFA in order to examine the relationships between the factors (Chapter 6).

During the exploration of RQ2, descriptive and inferential statistics were used to further analyse the quantitative data collected by the parent survey, along with an additional survey administered to child learners, in order to ascertain the learner requirements. Descriptive and inferential statistics were also used for analysis of the questionnaires administered during the design experiments. This process is reported in detail in the relevant Chapters (0 and 10).

Qualitative data was collected from the expert focus group described in Chapter 4 and across multiple instruments during the Design Experiments (Chapter 10). The data analysis process used was common to all of these and is described here with the details of its implementation and findings given in the relevant chapters.

For the qualitative data, content analysis, which also allowed for emergent themes, was performed. Krippendorff defines content analysis as “a research technique for making replicable and valid inferences from data to their context” (2018, p. 403). The requirement of replicability, or reliability, can be an issue in qualitative research (Campbell et al., 2013; Tashakkori et al., 1998) where the units of analysis (words) may have multiple meanings some of which may be context-dependent (Miles & Huberman, 1994). Hsieh & Shannon outline how this can be dealt with through the “systematic classification process of coding and identifying themes or patterns” (2005, p. 1278). They continue by describing three different approaches to this process: (1) conventional content analysis, an inductive approach where codes are derived from the data, (2) directed content analysis, where codes are defined from theory or relevant research findings, and (3) summative content analysis where the appearance of keywords is analysed for patterns which can lead to interpretations of the contextual meanings of those terms.
Directed Content Analysis is particularly useful in situations where there is existing research about a phenomenon, but it is incomplete or needs further exploration. It is a deductive approach which uses this theory or existing research findings to identify key concepts and variables that can usefully be employed as coding categories (Moretti et al., 2011). In the case of the expert focus group, existing analogous research was used to identify these categories. The categories for the Design Experiments, then, were identified based on their aim of further validating or extending conceptually the draft Design Principles (which are theoretically grounded in the survey findings (Chapter 6) and prior research and theory outlined in the literature review (Chapter 7)). This kind of analysis, which is operationalised based on previous knowledge is particularly suitable for this kind of “theory testing” (Elo & Kyngäs, 2008, p. 107).

Preparation for the analysis began by gathering and organising the data. The written material was then read through several times in order to become immersed in the data and get a “sense of the whole” (Elo & Kyngäs, 2008, p. 109). Following this the analytical process described by Campbell et al. (2013) was followed. This recommends using three stages and two researchers to code and theme text into a model. The first step in the process was predominantly deductive and involved developing a set of pre-determined codes related to the key concepts under investigation (although this was left open to evolve through reading text responses). The second step involved generating and assigning codes to text which were evaluated through intercoder agreement; and the third step involved clustering codes into sub-themes and themes that were peer reviewed and validated by two coders. This was supported through the use of qualitative analysis software NVivo 12 Plus. Data that could not be coded was then identified and analysed to determine if they represented a new category or a subcategory of an existing code. This is important as, as Hsieh & Shannon point out, these newly identified categories can “offer a contradictory view of the phenomenon or might further refine, extend, and enrich the theory” (Hsieh & Shannon, 2005, p. 1283). This can help mitigate the limitations of directed content analysis. As Krippendoff (2018) points out, if categories are derived from a theory, findings tend to ignore the “symbolic richness and uniqueness” of the data as researchers tend to approach the data looking for evidence that is supportive of that theory. However, conversely, if the categories are purely obtained from the data (inductive approach) then the findings are not generalisable much beyond the given data.

Finally, the quantitative and qualitative findings were triangulated to directly address the research questions (Chapter 11).
3.6 Research Design Summary

A summary of the Research Design is presented below in Figure 3.6. A mixed methods methodological approach rooted in a Pragmatic research philosophy led to an interrogation of the research questions to determine the appropriate research strategy. DBR’s interventionist orientation along with what Plomp (2013) refers to as its “twofold yield” of refining both theory and practice, provided the rationale for its choice to structure and organise the research. This was broadly guided by Reeves’ (2000) outline of the DBR process (Figure 3.2) as a cyclical one involving analysis of the problem, the development of solutions, the evaluation of those solutions in practice, and reflection on the outcomes.

![Figure 3.6 Research design summary](image)

While DBR provides an appropriate and potentially effective strategy to conduct this research, certain methodological limitations must be considered. Some of these are a feature of mixed methods methodology and some more specific to DBR. These will be discussed in the following section along with procedures that were put in place to mitigate their impact. Limitations that arose while conducting this study, in other words those that are specific to the implementation and findings of this study, will be discussed in the relevant chapters.
3.7 Quality of the Research

In general terms, ‘quality’ here refers to the soundness of research, or the extent to which the measures that are used to produce results adhere to a particular series of standards. Whatever standards are chosen to verify research results (see Yin (2009); Guba and Lincoln (2011)), it is important to consider the steps that are taken to establish quality. This section will identify potential threats to the quality, or limitations, of this research and outline the measures applied to quantitative and qualitative data sets to mitigate these.

3.7.1 The Role of the Researcher

The role of the researcher in DBR can be particularly problematic: “If a researcher is intimately involved in the conceptualization, design, development, implementation, and researching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge.” (Barab & Squire, 2004, p. 10). The researcher, being ‘interpretivist’, is never completely objective, indeed he or she is considered part of the research process, which means it is not possible to make any DBR research value-free.

DBR takes a holistic view of the subject under examination and the many variables included in the study cannot be considered outside their context or without consideration of their relationships. The role of the researcher, then, is further complicated by the fact that the Design Experiments take place in real-world settings. While the researcher may be intimately bound up in the DBR process, this may nevertheless mean that the researcher is considered an ‘outsider’ (Berger, 2015) in the setting of the research and that participants are hesitant to be completely open. McKenney et al. (2006) point to the importance of collaboration and mutual beneficial activities to gain participants’ trust and thorough understanding of the context (i.e. an ‘insider’ perspective). On the other hand, they also point to the advantages of being an outsider as this may benefit objectivity and provide “freedom (or forgiveness) for honesty that is not permitted to those within a particular group” (2006, p. 132)

The evolving role of the researcher in DBR reinforces the importance of continuing a reflexive practice throughout. This process was started with the initial consideration of the researcher’s positionality discussed in Section 1.6 and continued through ongoing reflexivity facilitated by the keeping of a research diary. This acknowledgement that the researcher’s role within the study may have potentially impacted various aspects of the research necessitates further measures to ensure consistency and integrity. These measures are described in the following sections.
3.7.2 Validity & Reliability

Writers on mixed methods advocate for ensuring the quality of both the quantitative and qualitative phases of the study (Creswell, 2009; Tashakkori et al., 1998). Statistical measures are generally used to verify the accuracy of numerical data sets and establishing validity requires consideration of the constructs that are to be ‘measured’, and analysis of the relevant tests that are required to verify the accuracy of the results. This process will be utilised in later chapters to assess the legitimacy of any quantitative findings.

While validity, reliability and generalisability are the concepts most often called on to confirm the quality of quantitative research, these concepts can be somewhat challenging to apply to qualitative studies. This section discusses some of these challenges, particularly in relation to DBR, and outlines any steps taken in this research to lessen their effects.

Lincoln & Guba (1985) argue that a sound methodological argument in the social sciences should instead touch on issues of credibility, transferability, dependability, and confirmability. Schoenfeld (1992) suggests the consideration of trustworthiness, credibility, and usefulness as well as the range of contexts to which the researcher believes the assertions should extend. While Creswell (2009) is happy to use the terms ‘reliability’ and ‘validity’ for qualitative research, he does argue that they have different connotations in this context.

Qualitative reliability looks to ensure that the research approach is consistent across different researchers and contexts. Yin (2009) suggests careful recording the procedures of the research and to document as many of the steps of the procedures as possible. This was done in this research and included setting up detailed protocols for collecting, storing and analysing data. The research also followed Creswell’s advice and developed an initial qualitative codebook, crosschecked codes, and employed a second coder to ensure intercoder agreement (2009 citing Gibbs(2018)). Finally, detailed reporting of the data collection and analysis procedures are provided here in order to provide a clear and accurate picture of the methods used. The iterative nature of DBR poses particular challenges for reliability as each cycle takes the findings of previous one into account. This means that the research design may also have to be refined as the study progresses. McKenney et al.(2006) present a few guidelines for conducting DBR that may help researchers in monitoring the quality of the research under these circumstances which were adopted here. These include having an explicit conceptual framework (based on review of literature, interviews of experts, studying other interventions) and developing a corresponding study design, i.e. applying a strong chain of reasoning for any developments in the research design.
Maximising qualitative validity entails using certain procedures to check the research for accuracy of the findings. Lincoln and Guba (1985) suggest that these include prolonged engagement and persistent observation, triangulation, peer debriefing, negative case analysis, and member checking. Creswell (2009) adds thick description, reflexivity, and a final external audit to this list. Because of time and resource limitations, a final audit was not possible. However, the other procedures were followed to the fullest extent possible as outlined below in Table 3.4.

<table>
<thead>
<tr>
<th>Validity Procedure</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflexivity</td>
<td>The researcher bias was interrogated at the outset of this study and is articulated in writing in Section 1.6 with a further consideration of the role of researcher in DBR in Section 3.7.1. Reflection on this role took place throughout, facilitated by the keeping of a research diary.</td>
</tr>
<tr>
<td>Triangulation</td>
<td>Data collection and analysis involved multiple instruments and included both qualitative and quantitative data.</td>
</tr>
<tr>
<td>Prolonged engagement and persistent observation</td>
<td>Data was collected over multiple iterations of similar phenomena and settings.</td>
</tr>
<tr>
<td>Negative case analysis</td>
<td>A constant comparison approach to the qualitative data analysis was taken. This involved comprehensive data treatment and dealing with negative or deviant cases (Gibbs, 2018).</td>
</tr>
<tr>
<td>Thick description</td>
<td>Full, context-rich descriptions of the context, design decisions and research results were provided.</td>
</tr>
<tr>
<td>Member checking</td>
<td>Informal follow-up with the participants to provide them with an opportunity to comment on the findings (for the expert focus group only).</td>
</tr>
<tr>
<td>Peer debriefing</td>
<td>Meetings with the PhD supervisor as well as team meetings, project steering committee meetings and working on joint publications ensured consideration of interpretations beyond the researcher.</td>
</tr>
</tbody>
</table>

Table 3.4 Validity procedures

3.7.3 Generalisability
Caution is needed about generalising beyond the groups and settings examined in qualitative research. Statistical generalisation from sample to population, as in the case of quantitative research, is generally not possible in qualitative research (Creswell, 2009; Gibbs,
2018). How then, can we argue for the applicability of the findings for a wider range of circumstances beyond those studied in this particular research?

Yin (2009), in his discussion of the issue in case studies, argues that ‘analytic generalisation’ can be claimed if the empirical results of a study back up or replicate a previously developed theory. In other words the research can aim for generalisation to a theory, model or concept by presenting findings as particular cases of that broader theory (Yin, 2009). Plomp (2013) suggests that this is also possible in the case of DBR and the researcher should strive to widen the domain of validity beyond that of the local instruction theory. Paraphrasing Yin (2003, p.37), design principles and local instruction theories must be tested through replications of the findings in subsequent cases in various contexts with the purpose of ensuring that the same results should occur. Once such replications have been made, the results might be accepted for a much larger number of similar contexts, even though further replications have not been performed.

In many ways then, rather that talking of generalisability in the context of DBR, it is more appropriate to speak of ‘transferability’ or ‘replicability’. According to van den Akker, the generalisability of findings increases when they are validated in "successful design of more interventions in more contexts“(1999, p. 9). In other words, while theory generated from DBR is usually developed for a specific domain, e.g. PI in CS Education, it must be general enough to be applicable in many different learning environments.

However, while DBR should aim to have applicability beyond the immediate problem setting and context through evolving relevant theory and generating new findings, it should be noted that, because theories developed in DBR are typically tied to those specific contexts and learning goals, they are modest and hard to generalise. Despite the fact that the emerging design principles or local theories may have been supported by a number of replications, and a new context may be similar to the ones from which these have emerged, each context has unique characteristics that may only justify the use of design principles as ‘heuristic’ statements. That is statements that provide guidance and direction, but do not give ‘certainties’. The same applies for local theories.

This idea is related to Schoenfeld’s (1992) criterion of ‘usefulness’. Whereas his first two criteria (trustworthiness and credibility) are akin to reliability and validity but do not necessarily require the use of objective and quantitative methods for demonstrating they have been met, the term ‘usefulness’ is less commonly invoked when determining the strength of a researcher’s claims (Dewey, 1938; Messick, 1992). Bakker and Eerde argue that
a core characteristic of DBR is that the theory under development “has to do real work” (2015, p. 15) and a final measure of research quality here is to obtain research results that are validated through the consequences of their use, or what Messick (1994) terms consequential evidence or validity.

3.7.4 Conclusion
The previous sections have outlined how this research has considered issues of quality, particularly in the context of the chosen DBR strategy. Chapters 6 and 11 which report on the findings of the two phases of the research will discuss limitations that relate to these, that arose in the implementation of those phases. These include such things as sample selection, sample size, and bias in data collection and analysis.

Finally, while much effort has been made to maximise the rigour of this research, it should be once again noted that all of this is limited by the scope of the study which is exploratory in nature and further explanatory and confirmatory investigation is planned for later cycles as outlined in Section 12.3 Future Research.

3.8 Research Ethics
The very nature of much educational research, particularly that conducted in an authentic context, inevitably invites ethical dilemmas into the research process. Ryen (2011) identifies consent, confidentiality and trust as the three main issues most frequently raised. Others relate to issues such as access to and recruitment of participants, ownership and sharing of data and compensation among others. Of primary importance is the obligation the researcher has to respect the rights, needs, values, and desires of the participants (Creswell, 2009). A thorough consideration of these issues was required in order to ensure that the research procedures of this study adhered to the ethical standards mandated by the School of Computer Science & Statistics, Trinity College. Three separate applications for approval of the research procedures to the School Research Ethics Committee were submitted. The first concerned the expert focus group described in Chapter 4 and the execution of the surveys described in Chapters 5 and 0. The second covered the data collection for the family workshops and the third, the facilitator workshops (Table 3.5). All applications were approved in advance of conducting the research (see Appendix A).
### Table 3.5 Applications to the Research Ethics Committee

<table>
<thead>
<tr>
<th>Application Name</th>
<th>Scope</th>
<th>Date Approved by Research Ethics Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>OurKidsCode</td>
<td>Expert Focus Group</td>
<td>10/05/2018</td>
</tr>
<tr>
<td></td>
<td>Survey instrument</td>
<td></td>
</tr>
<tr>
<td>OurKidsCode Part 2</td>
<td>Family Workshops</td>
<td>09/07/2018</td>
</tr>
<tr>
<td>OurKidsCode Part 3</td>
<td>Facilitator Workshops</td>
<td>24/09/2018</td>
</tr>
</tbody>
</table>

These applications covered additional ethical considerations that arose due to the fact that some of the participants were children aged between 5 and 14. These involved trying to find the balance between protection and participation: to enable children to be heard without exploiting or distressing them, and protected, without silencing and excluding them (Alderson & Morrow, 2004). Data collected from these participants included a survey conducted for the learner requirements analysis discussed in Section 8.3 and family workshop observations and fieldnotes. In the case of the child survey, there was no direct research contact with children. Rather parents were the point of contact, with parents providing consent for their children to complete a section in the parent questionnaire or not. Subsequent to parental consent being provided, the children were provided with an age-appropriate information sheet and had to provide assent before they could proceed (Appendix D). In the case of the family workshops, it was made clear that parents would be the focus of the research with no data collected directly via survey or interviews from child participants. However, as the family interaction is an important focus of the research, the actions and behaviours of the children formed part of the observation and fieldnotes data collection. They also contributed to the artefacts produced during the workshops. All participants were provided with information sheets and signed consent/assent forms prior to the workshops in order to ensure informed consent.

### 3.9 Chapter Summary

This chapter began by clarifying the aims and scope of the research before moving to describe and provide a rationale for the adoption of a mixed-methods methodological approach utilising a DBR Strategy. How DBR provides a structure for conducting the research was then outlined, with a clear trajectory for the research being set out. This trajectory begins with an analysis of the problem, then moves to the development of solutions, the
iterative evaluation of those solutions in practice is then undertaken followed by reflection
the outcomes (T. C. Reeves, 2000). The Chapter continued to provide an overview of the
data collection and analysis procedures, while noting that subsequent chapters will explain
these processes in more detail.

This overview of the research design was followed by a discussion of the steps taken to
ensure the quality of the research. It identified potential threats to or limitations of the
research and outlined the measures applied to mitigate these. Finally, the chapter explained
how the ethical consideration of the study were addressed, particularly with regard to
participants who are minors.

What follows, in Chapters 4, 5, and 6, describes how this research addressed RQ1, the
identification of factors that have an impact on PI in CS Education.
4. Identification of Factors

4.1 Introduction

The process of engaging with RQ1, identifying parents’ computing attitudes and behaviours that have an impact on their attitudes towards PI in CS Education, began by consulting relevant literature. The analysis of the findings of this review was then triangulated with those of an expert focus group in order to establish a conceptual framework of possible factors and their relationships. This framework was then subject to further testing and validation in subsequent chapters.

Parts of this chapter have been based on a research publication (Bresnihan et al., 2021). While this was a collaborative paper, the work presented in this chapter was completed solely by the researcher with the exception of the employment of a Research Assistant to act as the second coder for data analysis of the expert focus group. This was done in order to increase validity and reliability.

4.2 Literature Review and Classification

4.2.1 Literature Review Process

A Literature Review was conducted in an effort to identify potentially relevant factors in the context of PI in CS Education. This review was again conducted in the iterative fashion (Sanders et al., 2019) described in Section 2.2. The initial search parameters included peer-reviewed journal articles and conference proceedings written in English. Keywords were identified beginning with general search terms such as: “‘Parental Involvement’ & “Computer Science Education’” and synonyms such as ‘Computing Education’, ‘parents’ and ‘parental engagement’. Databases relevant to education and technology, included ERIC (Education Resources Information Center), ACM Digital Library, IEEE, Science Direct and the academic search engine Google Scholar were searched. Strategies that had proven effective in the previous literature review (Chapter 2) such as “pearl growing” (Petticrew & Roberts, 2008) and “Snowballing” (Ridley, 2012) were once again utilised.

A preliminary search revealed that the issue of PI in this context has not been adequately addressed. This was confirmed by McGill et al.’s Gap Analysis of non-cognitive constructs in evaluation instruments designed for computing education which found that the majority of
constructs were designed to measure Student Engagement and School Climate. Constructs measuring Social-Familial Influences occur the least, with only four out of the 132 unique constructs classified as PI constructs (McGill et al., 2019). It was therefore necessary to consult analogous research and widen the search to include more general technology (using keywords such as ‘ICT’ and ‘Digital Skills’) and look beyond parents to include learners and teachers.

4.2.2 Literature Review Findings

Previous studies concerned with factors that affect ICT competencies are, in the main, concerned with general technology skills rather than CS. They also tend to focus on teachers (Bingimlas, 2009) or learners (Aesaert et al., 2015; Goh, et al., 2015; van Braak, 2004; Vekiri, 2010; Vekiri & Chronaki, 2008; Wang et al., 2015; Wong, 2015; Zhong, 2011) rather than parents (Kong et al., 2019). In addition, when PI in CS Education is considered, research is generally focused on its effect on learners, rather than on the factors that impact on its nature and quality. For example, the extensive digital competence (EDC) model (Aesaert et al., 2015) does identify parental ICT support, parental ICT attitude and ICT availability in the home as factors in developing ICT competencies in children but does not explore any possible relationship between these factors. Zhong postulates that that “the family works as a more powerful predictor of adolescents’ self-reported digital skills than schools do” (2011, p. 745). However, he attributes this to the fact that students tend to use the computer and the Internet at home far more often than they do at school rather than PI.

However, these studies do reveal factors that have an effect on teacher technology integration and its role in children’s ICT competencies which may be applicable to parents. Aesaert et al. (2015) reveal teachers’ self-reported ICT competence as a factor that is positively related to their students’ ICT self-efficacy, and that teachers’ negative attitude towards ICT is a barrier towards the integration of ICT. Vannatta & Bannister (2008) also identify a number of teacher-related factors for technology integration in the classroom that may apply to parents in the home context:

1. risk-taking behaviours and comfort with technology;
2. perceived benefits of using technology;
3. beliefs and behaviours about technology use;
4. technology use;
5. facilitation of student technology use; and
6. support for technology use and access to technology.
Similarly, Bingimlas’s (2009) meta-analysis of barriers to integrating ICT in schools identified confidence, competence and accessibility as the critical components of technology integration in schools.

A synthesis of these related studies, presented in Table 4.1, identified confidence, usage, experience and availability as computing-related factors that could be operationalised to examine the relationship between parental computing attitudes and behaviours in the family context and parental attitudes towards and motivation for PI in CS.

<table>
<thead>
<tr>
<th>Literature</th>
<th>Confidence</th>
<th>Usage</th>
<th>Experience</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aesaert et al. (2015)</td>
<td>ICT attitude</td>
<td>ICT use</td>
<td>ICT experience</td>
<td>ICT availability</td>
</tr>
<tr>
<td>Bingimlas (2009)</td>
<td>confidence</td>
<td>competence</td>
<td>accessibility</td>
<td></td>
</tr>
<tr>
<td>Cutts et al. (2018)</td>
<td>confidence</td>
<td>complexity of IT use</td>
<td>experience</td>
<td></td>
</tr>
<tr>
<td>Goh et al. (2015)</td>
<td>confidence; attitude</td>
<td>ICT use</td>
<td>ICT competency</td>
<td>home ICT access</td>
</tr>
<tr>
<td>Kuhlemeir &amp; Hemker (2007)</td>
<td>use</td>
<td>home access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Van Braak (2004)</td>
<td>computer confidence</td>
<td>Variety of computer applications</td>
<td>computer experience expressed in time intensity of use</td>
<td>home access to a computer</td>
</tr>
<tr>
<td>Vannatta &amp; Banister (2008)</td>
<td>risk-taking behaviors; comfort with technology</td>
<td>technology use</td>
<td>technology competency</td>
<td>support for technology use; access to technology</td>
</tr>
<tr>
<td>Vekiri &amp; Chronaki (2008)</td>
<td>computer self-efficacy</td>
<td>variety of activity</td>
<td>frequency of computer use</td>
<td>access</td>
</tr>
<tr>
<td>Vekiri (2010)</td>
<td>ICT self-efficacy</td>
<td>Information systems (IS) instruction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang et al. (2015)</td>
<td>self-perception</td>
<td>activity variety</td>
<td>academic exposure frequency of use</td>
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</tr>
<tr>
<td>Wong et al. (2015)</td>
<td>self-efficacy</td>
<td></td>
<td>exposure to field; opportunities to program</td>
<td>facilitating conditions</td>
</tr>
<tr>
<td>Zhong (2011)</td>
<td>ICT usage</td>
<td>length of previous experience</td>
<td>school ICT access; home ICT access</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.1 Identification of potential predictor factors using analogous literature
4.3 Expert Focus Group

Consultation with experts or members of the target population using the focus group methodology can be an effective way of informing the initial identification and specification of key constructs (Haynes et al., 1995; Vogt et al., 2004). To this end, a qualitative study using an in-depth face-to-face focus group was undertaken, with a purposive panel of domain experts, in order to establish face validity for both the factors and the causal hypothesis identified. The proposition that qualitative methods can be used for suggesting causal hypotheses or providing supporting data for “causal” quantitative research is widely accepted (e.g., by Towne & Shavelson (2002)). Maxwell (2004b) goes further and argues that qualitative methods can be used to identify causal relationships. His realist approach argues that adequate causal explanations in the social sciences depend on the in-depth understanding that qualitative research can provide.

Purposive sampling was undertaken and domain expert participants (n=5) including teachers, academics, and coding club mentors (all also parents) were gathered for in-depth discussion of the findings of the literature review and to share their expertise. Eleven constructs exploring inhibitors to parents using technology with primary age children (Goh, et al., 2015) were adapted into corresponding focus group questions in order to guide the discussion (Appendix B). The focus group was audio recorded, and written observation notes taken, with responses consolidated into a transcript for analysis.

The research followed the qualitative data analysis process described in Section 3.5.2 using three stages and two researchers (the researcher and another academic research staff member) to code and theme text into a model. The first step in the process was predominantly deductive and involved developing a coding scheme informed by the literature review (although this was left open to evolve through reading text responses); the second step involved generating and assigning codes to text which were evaluated through intercoder agreement; and the third step involved clustering codes into sub-themes and themes that were peer reviewed and validated by two coders. The clustering generated n=18 sub-themes, and n=4 themes and continued to fit the conceptual orientation developed from the literature, mapping to the four identified predictor factors. Each of the factors are discussed in turn below, with quotes from the transcript included to add context.

4.3.1 Confidence
Exploring parental confidence in computing was viewed by the participants as necessary to understanding barriers to involvement in their children’s computing education. One
particip
ant observed a "lack of confidence on the part of parents; (parents) don’t feel that they are confident in their own use of technology. When they get going, they can support their children". Another participant spoke of a “confidence and time deficit” on the part of parents and a third of the importance of “being comfortable using technology”.

4.3.2 Usage
The importance of creative and collaborative usage of technology for encouraging PI emerged strongly from all participants. One participant reflected that they had facilitated a successful workshop where families “were encouraged to use Makey-Makey, code it through Scratch, and make something interactive. (It was) tactile and hands on. (The focus was) on families working together”. A further participant agreed that collaborative technology created new opportunities for families to express their creativity, adding that workshops “need to appeal to strengths about design, creativity, and problem-solving capabilities”, and create an environment where “sharing needs to be encouraged, learning about roles, switching around - collaboration”.

4.3.3 Experience
Parental experience of technology was identified as playing a key role in their involvement in children’s use of technology. One participant argued that in order to get involved parents need the technical skills or the “know-how” to use technology in a home context. Another reflected that socio-demographics impact upon this experience, with some parents having a “higher chance of being in technology work”, while other parents may have “less self-belief and experience”. A further participant argued that parents can be perceived as ‘role models’ adding that it is "really important that parents are computing role models. Providing an opportunity for their children to see the value of computing as an option”. Parental experience was viewed as essential in providing encouragement, with one participant invoking “parents as guides” in learning experiences.

4.3.4 Availability
The importance of availability of technology for PI, emerged as a further theme from participants. One participant felt that it was important to understand what access families had to technology including computing resources and educational supports, pointing out that “parents might not have access to computing courses” and we “don’t know what technical set up at home so we need to help parents prepare for this”, while other parents may have access to different devices or “have lots of technical knowledge through using phones”. Moreover, one participant stressed the importance of understanding access to
technology and technology availability in order to design supports which "encourage parents not to limit their children in their creativity".

4.4 The Factors Conceptualised
This section seeks to further clarify what is meant by these constructs in the context of this research. This is done with reference to the literature review and further informed by the focus group findings.

4.4.1 Confidence
‘Confidence’ in the literature reviewed is sometimes used interchangeably with ‘self-efficacy’ (Aesaert et al., 2015). Self-efficacy beliefs are cognitive self-evaluations of ability to successfully perform tasks of a particular domain (Bandura, 1993). Self-efficacy beliefs have received particular attention in educational research and been shown to have a significant effect on the quality of student learning (Pintrich & De Groot, 1990) and to be important predictors of students’ academic choices and career pathways (Bandura et al., 2001; Eccles, 1994). Parental lack of a sense of efficacy for helping their child was identified as a general barrier to PI in Section 2.6.1 (Hornby & Lafaele, 2011). While, conceptual differences exist between the concepts (notably self-efficacy is usually taken to be domain-specific (Maclellan, 2014; Stankov et al., 2012)), this conflating of the terms is common and a decision was taken to use the term ‘confidence’ to refer generally to confidence in the ability to use or learn about computers. This was for two reasons, firstly it is in line with much of literature reviewed as well as the terminology used by experts during the focus group, and also it provides a more colloquial and easily-understood term for use with participants in the data collection process.

A lack of teacher confidence is identified by Bingimlas (2009) as a major barrier to the uptake of ICT in education. Conversely, comfort and risk-taking with troubleshooting and trying new technologies is demonstrated by teachers who effectively integrate technology into the classroom (Vannatta & Banister, 2008). Van Braak (2004) does not attempt to define computer confidence but does find that its direct impact on computer competence was stronger than either computer experience or intensity of computer use. Vannatta & Bannister’s construct “Risk-taking Behaviors and Comfort with Technology” measured emotional responses of comfort and anxiety when troubleshooting or risk-taking with new technology. Wong (2015) found that computer self-efficacy among pre-service teachers can impact behavioural intention of use. Wang et al. found that, for girls in particular, perceptions of their own proficiency in mathematics and problem-solving significantly had a
significant impact on their interest in CS-related degree programmes. The findings from the focus group reinforced the hypothesis that these findings could also apply to parents and a lack of confidence in their own use of technology could inhibit their engagement in CS activities with their children.

4.4.2 Usage
This construct refers to specific types of computer use. For example, Kuhlemeier & Hemker (2007) found that home use of e-mail and educational software were found to be positively related to student achievements but not gaming and listening to music. Goh et al. (2015) investigated the general use of devices by children, categorising them into leisure activities and school work. Vekiri (2010) distinguishes between ‘technical’ use and ‘social and collaborative’. For teachers, Vannatta & Bannister (2008) categorised usage into administration, communication, and instruction. Within these various categories, the types of activities investigated by researchers have evolved over the years as new technologies are developed and popularised (for example Vekiri & Chronaki (2008) list drawing, writing, game-playing, internet search, schoolwork, learning with educational software, programming, e-mail) making it difficult to directly compare findings. However overall, variety in use has been shown to have a positive correlation with technology uptake and from the focus group the possible importance of creative and collaborative usage of technology for encouraging PI emerged strongly.

4.4.3 Experience
‘Experience’ is positively related to competence in the literature; Bingimlas talks of experience in terms of “knowledge and skills” (2009, p. 238). It is often operationalised as the length of time a person has been using a computer or the daily/weekly amount of time spent using computers (Aesaert et al., 2015; Vekiri & Chronaki, 2008; Zhong, 2011). Others, such as Wang et al. (2015) look to academic exposure which he identifies as having a role in the choice of whether to pursue a CS-related degree. Cutts et al. (2018) use programming success and ease as a way of gauging experience that is more particular to CS Skills rather than general technical skills. As well as experience being important for skill levels, the idea of the experienced parent being a role-model for their child was raised by the focus group.

4.4.4 Availability
Availability, is often referred to as ‘access’ and generally refers to home computer ownership and good quality access to the internet (Aesaert et al., 2015; Kuhlmeier & Hemker, 2007; Vekiri & Chronaki, 2008). Home ICT access is positively related to adolescents’ self-reported digital skills (Kuhlmeier & Hemker, 2007; Zhong, 2011) However Bingimlas (2009) points
out even if hardware and software is available, poor organisation of resources, poor quality hardware, and inappropriate software or teaching materials can negate its positive impact on teacher uptake. Teachers also identify technical assistance and support policies as being important elements of access (Vannatta & Banister, 2008). Wong (2015) refers to these issues as ‘facilitating conditions’ and adds time and pedagogical support to the list. The focus group also believed that access to computing resources and educational supports were important and an understanding of the availability of these in the home context would be important to the design of any supports. Finally, the general finding from Section 2.6.1 that invitations and opportunities for PI can also influence the level of that involvement should be considered here (Hoover-Dempsey & Sandler, 1997).

4.4.5 PI Attitudes & Motivation

The examination of the barriers to PI in Section 2.6.1 revealed parents’ beliefs about PI to be a notable determinant of their levels of involvement. Expectancy-value theory, or the idea that all available choices are compared regarding their expectancies of resulting in goal attainment and the values of the goals, has been widely and effectively used over the past 70 years to predict and explain human choice (Weiner, 1991). Operating within this theory, Eccles’ model of achievement-related choices has been tested in several studies and has emerged as an effective theory in predicting, on a general level, a student’s choice of both school subjects, such as mathematics and computer courses (Dickhäuser & Stiensmeier-Pelster, 2003; Eccles, 1994), and leisure activities (Eccles & Harold, 1991). This model uses the incentive value of anticipated success, or task-value beliefs, to investigate students’ reason for engaging in those tasks. These comprise their beliefs about the enjoyment or importance of the activity, the usefulness (utility value) and the cost involved in performing tasks of a particular domain (Eccles & Wigfield, 1995).

The importance of role-construction or what activities parents will value as important or appropriate in relation to their child’s education (Hornby & Lafaele, 2011), to PI in general, noted in Section 2.6.1, points to the potential application of this model here. This research therefore explores the importance of the intrinsic and attainment value and perceived utility of CS Education to parents’ choice to get involved.

PI attitudes & motivation in the context of this research, then, refers to parents’ expressed beliefs about involvement in their child’s CS Education (Aesaert et al., 2015) with ‘attitudes’ encompassing intrinsic and attainment value beliefs and ‘motivation’ referring to perceived utility. People are more likely to engage in tasks and to pursue activities that they consider
interesting, important and useful to them (Wigfield et al., 2009). These values or beliefs affect task choice and engagement.

In the domain of computing education, Vannatta & Bannister’s (2008) investigation of teacher’s beliefs about classroom technology use found a moderate to strong correlation of general beliefs that support technology integration with teacher technology use for instruction. This, they argue, supports the use of belief items related to technology use in the measurement of technology integration. Bingimlas (2009), when discussing ICT integration into teachers’ practice identified teachers’ resistance to change and negative attitudes as a barrier. However, he concludes that these beliefs were a result of the lack of experience, availability and confidence while Vekiri & Chronaki (2008) found that experience and usage were related to girls’ task-value beliefs. The literature therefore suggests the causal hypothesis that an increase in these factors may have a positive impact on PI Attitudes and Motivation (Figure 4.1).

The literature review identified confidence, usage, experience and availability as possible relevant factors situated in the home-computing context. It also served to clarify the understanding of these factors. The expert focus group confirmed that these findings were consistent with their expert experiences and provided verification that the factors identified were potentially ones that would impact on PI attitudes and motivation. Furthermore, the qualitative data was used “to both enrich and extend” knowledge of these factors and inform their conceptualisation (Vogt et al., 2004). The literature reviewed also provided instruments which could be adapted for use in this context. The following chapter outlines the development of the parent survey instrument to measure these factors.

4.5 Chapter Summary

The literature review identified confidence, usage, experience and availability as possible relevant factors situated in the home-computing context. It also served to clarify the understanding of these factors. The expert focus group confirmed that these findings were consistent with their expert experiences and provided verification that the factors identified were potentially ones that would impact on PI attitudes and motivation. Furthermore, the qualitative data was used “to both enrich and extend” knowledge of these factors and inform their conceptualisation (Vogt et al., 2004). The literature reviewed also provided instruments which could be adapted for use in this context. The following chapter outlines the development of the parent survey instrument to measure these factors.
5. Survey Instrument Development

5.1 Introduction

The next step in the research involved the development of the parent survey instrument. The original survey included 19 items that aimed to investigate: parents’ computing confidence (nine items); usage (three items); experience (three items); and availability (four items). It also contained ten items relating to the outcome variables: attitudes towards PI in CS Education (seven items); and motivation for PI in CS Education (three items). In addition, the survey included seven items requesting demographic information. The items were presented in mixed order.

Where possible, items for scales were adapted from existing, validated instruments as outlined in Table 5.1. While, as previously mentioned, the issue of PI in CS Education has not been adequately addressed, the instruments that engaged with children’s and teachers’ attitudes and behaviours, identified during the literature review, were examined for comparable scales as described for each factor in Section 5.2 below. The findings from the expert focus group further informed the adaptations.

Following the process of exploratory and confirmatory factor analysis described in Section 5.4, some of the original items were combined or split to form a reliable and valid instrument to measure the following seven factors: parental computing confidence, experience, usage of technology for creation, usage of technology for consumption, availability of technology, attitude to PI in CS Education and motivation for PI in CS Education. The final, 24-item, validated instrument (Parental Involvement in Computer Science (PICS) Survey Instrument) can be viewed in Appendix C.

This chapter begins by explaining the development of the survey items to measure the identified factors and how the survey was distributed to the target population of parents. Section 5.4 then outlines how the validity and reliability of the survey was statistically established. Parts of this chapter and Chapter 6, which discusses the survey findings, have been based on a research publication (Bresnihan et al., 2021). While this was a collaborative paper, the work presented in these two chapters was completed by the researcher with the exception of the statistical tests described in Sections 5.4, 6.2 and 6.3 which were performed and described by a colleague in order to assist in validating the conceptual model.
5.2 Item Development

5.2.1 Predictor Variables (Computing Attitudes and Behaviours)

5.2.1.1 Confidence
Items that measure parental computing confidence were adapted from those relating to teachers’ risk-taking behaviours and comfort with technology in the Teacher Technology Integration Survey (TTIS) (Vannatta & Banister, 2008) and those looking at the link between early childhood experiences and later confidence in computing in Cutts et al. (2018). Participants were asked to rate their level of agreement from strongly disagree to strongly agree, on a five-point, Likert-type scale with statements such as “learning new things on the computer is confusing for me” and “I feel comfortable about my ability to work with computers”.

5.2.1.2 Usage
Items concerning computing usage were adapted and updated from English DfES surveys on ICT usage directed at young people (Hayward et al., 2002). These looked at usage patterns (time and purpose). Of particular interest, given the research focus on CS rather than digital literacy or general ICT skills, was the nature of the tasks undertaken by parents. Respondents were asked to select the activities for which they used their devices in the home. Following the process of factor analysis outlined in Section 5.4, the modes of usage were categorised as: creation (website development, programming, etc.) and consumption (internet use, social media, online shopping, etc.). For the purposes of analysis, the creation and consumption factors were calculated by summing associated responses.

5.2.1.3 Experience
As the context of the study is CS Education rather than general ICT skills, this particularly referred to programming experience. This item explored perceived programming competency level (Cutts et al., 2018).

5.2.1.4 Availability
Items relating to computing availability were also adapted from Hayward et al. (2002). They were designed to gauge access to various devices and adequacy of internet provision. For the purposes of analysis, the overall number of devices and the internet quality in the home were considered as predictor variables.

5.2.2 Outcome Variables (Attitudes towards and Motivation for PI)

5.2.2.1 Attitude towards PI in CS Education
As previously noted, there is very little research that engages directly with this construct. Since this research project began, Kong et al. (2019) published a scale to measure parents’ perceptions of programming education in schools. While this is a valuable contribution to
understanding the role that parents play in CS Education, it differs from the current study in that it focuses on parents’ perceptions of programming in the school context, rather than how computing attitudes and behaviours in the home relate to PI.

While no existing scales existed for this factor, Aesaert’s development of the extensive digital competence (EDC) model and scale for Primary school pupils’ ICT competences was useful; it takes the broader classroom and school context in which pupils are embedded into consideration, and includes the impact of parental support (Aesaert et al., 2015). The EDC scale in conjunction with an exploration of secondary school pupils’ value and efficacy beliefs about computers (Vekiri, 2010), were adapted for the relevant items in the instrument encompassing intrinsic and attainment value beliefs. The items are again rated on a 5-point Likert scale in which participants were asked questions that related to their attitude towards PI in computing, such as “I want to help my child understand what programming does” and “I want my child to have fun when learning about computers”.

5.2.2.2 Motivation for PI in CS Education
The EDC model’s parental and teacher ICT attitude scales were also adapted to explore the reasons why parents might wish to get involved in their children’s CS Education (Aesaert et al., 2015). These related to the perceived utility of such involvement as discussed in Section 4.4.5.

<table>
<thead>
<tr>
<th>Variable Type</th>
<th>Factors</th>
<th>Overview</th>
<th>Scales Adapted</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-computing/ Demographics</strong></td>
<td>Gender, Age, County, Main Role, Occupation, No. of children in primary school, their ages &amp; genders</td>
<td>Generic Markers used across instruments designed by Research Centre.</td>
<td></td>
</tr>
<tr>
<td><strong>Predictor Variables</strong></td>
<td>Confidence</td>
<td>Ease and enjoyment of computer use</td>
<td>Cutts et al.(2018); Vannatta &amp; Banister (2008)</td>
</tr>
<tr>
<td></td>
<td>Usage</td>
<td>Time, task, purpose</td>
<td>Hayward et al.(2002)</td>
</tr>
<tr>
<td></td>
<td>Experience</td>
<td>Qualifications, Programming experience</td>
<td>Cutts et al.(2018)</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
<td>Devices, Internet access</td>
<td>Hayward et al.(2002)</td>
</tr>
<tr>
<td></td>
<td>Attitude towards PI in CS Education</td>
<td>How parents feel about getting involved with their children’s CS activities?</td>
<td>Aesaert et al.(2015); Vannatta &amp; Banister(2008)</td>
</tr>
<tr>
<td></td>
<td>Motivation for PI in CS Education</td>
<td>Why do they want to get involved with their child’s CS activities?</td>
<td>Aesaert et al.(2015)</td>
</tr>
</tbody>
</table>

Table 5.1 Item development
5.3 Survey Distribution

Previous research has shown that (a) ICT competencies should be taught at an early age (Aesaert et al., 2015; McClure et al., 2017) and (b) that PI is more effective the earlier it occurs (Sylva et al., 2004). This study therefore identified the parents of primary school pupils (age 4-13) in Ireland as its target population.

The survey was first pre-tested with five members of the target population and a number of small adjustments were made to the language to improve consistency and understanding. The questionnaires were then distributed online in July and August 2018. This was done through interested parties such as the National Parents Council (NPC), the Computers in Education Society of Ireland (CESI) and the Irish Department of Rural & Community Development (DRCD) to approximately 10,000 parents of primary school children across Ireland. It closed having been completed by 1,228 parents, a response rate of just over 10%. Responses were received from every county in Ireland. The majority of respondents were female and in the age range 36-45 years old (Figure 5.1).

Most of the respondents had two (40%) or three (41%) children of primary-school age, with a male to female ratio amongst the children of 54% to 46%. Of the respondents, 71% were in full-time employment, with 21% working in the home. Twenty-one percent of respondents identified as having a computing qualification (79% did not), with 68% reporting never having tried to programme at all. This level would appear to be higher than that of the general population in Ireland, of who 14% identified STEM related subjects as their field of study in 2020 (Condron, 2020). The limitations of the sampling procedures are discussed in Section 6.4.

![Figure 5.1 Participant gender and age range](image)
5.4 Validity & Reliability

Factor analysis is a process that provides information about reliability, item quality and construct validity. The primary goal of factor analysis is to determine whether, and to what extent, the items in a scale represent an underlying construct, or factor. Exploratory factor analysis (EFA) is used to uncover the underlying structure of a set of variables, and confirmatory factor analysis (CFA) can be computed to examine how well the hypothesised factor structure fits the data. In this study, a cross-validation approach that combined EFA and CFA was conducted to analyse the factor structure of the potential confidence, usage, attitude to PI and motivation for PI scales.

Depending on the variable type, one of two methods of exploratory factor analysis was conducted. As the confidence, attitude and motivation variables scales could be considered continuous, a principal access factoring method, using the statistical software package SPSS24©, was used for the exploratory factor analysis. A Robust Unweighted Least-squares method conducted using the FACTOR program\footnote{http://psico.fcep.urv.es/utilitats/factor/Description.html}, was used for the dichotomous usage scales (Baglin, 2014). Items that measured experience and availability were not combined into scales and did not therefore require factor analysis. In the factor analysis, coefficients with an absolute value lower than 0.3 were suppressed and not included in the scale development.

Two random samples of approximately equal size were obtained from the data gathered using SPSS. Following analysis of the patterns of missing values in the variables it was shown that there were 572 missing values (3.3% of the data), with no variable having more than 10% missing. Missing values were addressed through a process of multiple imputation (Jakobsen et al., 2017) and no participants were eliminated from the study at this point.

5.4.1 Confidence, Attitude to PI and Motivation for PI

In order to establish the validity of the confidence, attitude to PI and motivation for PI factors, an EFA was conducted using SPSS on the first random sample (n=591). The suitability of the data for factor analysis was confirmed prior to running the tests: the Kayser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.91, exceeding the recommended minimum value of 0.5, and Bartlett’s test of Sphericity was highly significant (<0.001) (Field, 2009).

The Principal Axis Factoring (PAF) extraction method with Direct Oblimin rotation was used in order to identify the underlying factor structure of confidence, attitude to PI, and
motivation for PI scales. This extraction method was selected as the data exhibited z-values for skewness outside the recommended levels of ±1.96 for all items. An oblique rotation was utilised as the factors were not expected to be orthogonal (Field, 2009; Worthington & Whittaker, 2006). Three factors with eigenvalues greater than 1 were extracted, explaining 34% and 14% and 4% of the variance respectively. The number of dimensions was confirmed by the scree plot (Figure 5.2). The rotated solution (Table 5.2) explained a total of 51.4% of the variance.

![Scree Plot](image.png)

**Figure 5.2 Scree plot**

<table>
<thead>
<tr>
<th>Survey Item</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Confidence – Anxious using tech</td>
<td>0.850</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Confidence – Able to troubleshoot</td>
<td>0.804</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Confidence – Confident to learn</td>
<td>0.789</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Confidence – Learning tech confusing</td>
<td>0.771</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Confidence – Need to follow steps</td>
<td>0.711</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Confidence – Comfortable with tech</td>
<td>0.710</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Confidence – Others set up tech</td>
<td>0.672</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Confidence – Need help</td>
<td>0.651</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Attitude – Anxious with kids and tech</td>
<td>0.485</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>Attitude – Want to spend time with kids</td>
<td></td>
<td>0.721</td>
</tr>
<tr>
<td>30</td>
<td>Attitude - Want to learn as a family</td>
<td></td>
<td>0.674</td>
</tr>
<tr>
<td>24</td>
<td>Attitude – Excited to make with kids</td>
<td></td>
<td>0.659</td>
</tr>
<tr>
<td>28</td>
<td>Attitude – Want kids to understand</td>
<td></td>
<td>0.555</td>
</tr>
<tr>
<td>26</td>
<td>Attitude – Often use with kids</td>
<td></td>
<td>0.544</td>
</tr>
<tr>
<td>27</td>
<td>Attitude – Want kids to have fun</td>
<td></td>
<td>0.495</td>
</tr>
<tr>
<td>36</td>
<td>Motivation - Opportunity to experience tech</td>
<td></td>
<td>0.718</td>
</tr>
<tr>
<td>35</td>
<td>Motivation – Inform about jobs</td>
<td></td>
<td>0.661</td>
</tr>
<tr>
<td>34</td>
<td>Motivation – Inform about computers in society</td>
<td></td>
<td>0.612</td>
</tr>
</tbody>
</table>

*Extraction Method: Principal Axis Factoring.*  
*Rotation Method: Oblimin with Kaiser Normalization.*  
*a. Rotation converged in 11 iterations.*
Factor 1 relates to parents’ own level of confidence in using technology; factor 2 groups items that relate to attitudes to PI in CS Education; and factor 3 relates to motivation for PI in CS.

In order to explore the internal consistency of each of the factors, their Cronbach’s alphas were calculated. All three scales were found to be highly reliable, with alpha coefficients for the 9 confidence, 6 attitude, and 3 motivation items of .91, .82 and .75 respectively.

As the EFA indicated that there were three distinct factors, a confirmatory factor analysis (CFA), shown in Figure 5.3, was conducted using SPSS AMOS© Graphics software on the second random sample (n=558). Goodness-of-fit of the model was assessed using a chi-square test, the root-mean-square error of approximation (RMSEA), the Comparative fit index (CFI), and the Tucker Lewis index (TLI).

![Figure 5.3 CFA for the three-factor model of parental computing confidence, attitude to PI, and motivation for PI](image-url)
Chapter 5. Survey Instrument Development

The overall fit of the three-factor model was good. Although the chi-squared test was significant, this test is highly sensitive to sample size and skewness and should not serve as the sole basis on which to judge the goodness of fit (Schermelleh-Engel et al., 2003). The CMIN/df=3.3, and for large sample sizes values less than 5 are deemed reasonable (Wheaton et al., 1977), particularly when descriptive goodness-of-fit indices are also considered. Table 5.3 outlines the values for the descriptive goodness-of-fit indices considered in this study (Hu & Bentler, 1999; Schermelleh-Engel et al., 2003; Wheaton et al., 1977).

<table>
<thead>
<tr>
<th>Fit Measure</th>
<th>Value</th>
<th>Goodness-of-fit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMIN/df</td>
<td>3.3</td>
<td>Reasonable</td>
</tr>
<tr>
<td>RMSEA</td>
<td>0.064</td>
<td>Acceptable</td>
</tr>
<tr>
<td>CFI</td>
<td>0.933</td>
<td>Good</td>
</tr>
<tr>
<td>TLI</td>
<td>0.914</td>
<td>Good</td>
</tr>
</tbody>
</table>

Table 5.3 Goodness-of-fit evaluation

5.4.2 Usage

In order to perform EFA on the dichotomous usage variable, the FACTOR program was used on the first sample, to conduct Robust Unweighted Least-squares exploratory factor analysis based on tetrachoric/polychoric correlations. This is accepted as being a robust, defensible and widely used approach for performing item analysis of this kind (Aletras et al., 2010). CFA was then conducted using SPSS AMOS© Graphics software on the second random sample (n=558) (Figure 5.4).

![Figure 5.4 CFA for the two-factor model for usage in terms of creation and consumption](image-url)
Goodness-of-fit of the model was assessed using a chi-square test, the root-mean-square error of approximation (RMSEA), the Comparative fit index (CFI), and the Tucker Lewis index (TLI). The overall fit of the two-factor usage model was good, with CMIN/df = 2.88, RMSEA = 0.058 and Standardized RMR = 0.052 (Hooper et al., 2008). This process identified two factors from the usage data that relate to consumption and creation.

5.5 Chapter Summary

This chapter described the development of a Parent Survey instrument aimed at identifying parents’ computing attitudes and behaviours that have an impact on their attitudes towards PI in CS Education. Following its distribution to parents across Ireland, factor analysis of the n=1228 responses collected enabled the identification of its underlying structure and confirmed that the items used in the survey did indeed measure parental confidence and usage, as well as their attitude to, and motivation for, PI. However, the analysis revealed two distinct factors from the usage data, namely consumption and creation. Having established the validity of these constructs, the following chapter describes the inferential analysis conducted on the second sample with the purpose of addressing RQ1 ‘What factors have an impact on parental attitudes towards PI in CS Education?’.
6. Survey Findings

6.1 Introduction
This chapter explores the possible relationships between the variables in this study and describes the attempt to identify significant predictors of positive parental attitude to and motivation for involvement in their children’s CS Education. This was achieved through correlation and regression analyses conducted on the second sample of the data collected.

6.2 Correlations
Correlation analysis measures the strength of association between two variables as well as the direction of the relationships. The strength of the relationship is indicated by the correlation coefficient ($r$), which can vary between + and - 1, and the direction is identified by the sign of the coefficient. A positive relationship indicates that as one variable increases, so too does the other. Pearson’s correlation coefficients were calculated using for all combinations of predictor and outcome variables, with any significant relationships reported below.

Positive correlations were identified between the attitude to PI and confidence scales ($r = 0.392$, $n = 530$, $p < 0.001$), and the level of motivation for PI and confidence scales ($r = 0.344$, $n = 519$, $p < 0.001$). Self-reported programming level (experience) and attitude to PI ($r = 0.330$, $n = 493$, $p < 0.001$) were also positively correlated, indicating that parents who felt more experienced were more likely to be positively disposed to being involved in their children’s CS Education. Positive correlations were also identified between experience and motivation for PI, but to a lesser degree ($r = 0.232$, $n = 488$, $p < 0.001$). Examination of other variables showed that there are positive correlations between numbers of devices in the household (availability) and attitude to PI ($r = 0.188$, $n = 530$, $p < 0.001$) and motivation for PI ($r = 0.178$, $n = 519$, $p < 0.001$) although these relationships are not quite as strong. Internet quality appears to have a small, but statistically significant correlation with attitude to PI ($r = 0.176$, $n = 521$, $p < 0.001$). Exploration of the relationships between the types of technology usage in the home and both attitude to PI and levels of confidence, also revealed significant positive correlations. Usage was broken down into the two categories of consumption (videos, music, games, social media, etc.) and creation (website development, programming, etc.). In order to be able to establish levels of usage in each of these categories, the scores
for each item in the section were summed to provide an overall score. This score ranged from 1 – 5 in creation and 1 – 8 for consumption, with significant correlations between all of the variables with the exception of creation and motivation for PI. The strongest correlations were between attitude to PI and both consumption ($r = 0.191, n = 526, p < 0.001$) and creation ($r = 0.197, n = 185, p < 0.001$). Similar, if slightly weaker, correlations were also identified between availability, level of programming experience and the usage of technology for consumption, and motivation for PI. The positive correlations are listed in descending order of their strength in Table 6.1 below.

<table>
<thead>
<tr>
<th>Positive Correlations (descending order of strength)</th>
</tr>
</thead>
<tbody>
<tr>
<td>confidence and attitude to PI</td>
</tr>
<tr>
<td>confidence and motivation for PI</td>
</tr>
<tr>
<td>experience and attitude to PI</td>
</tr>
<tr>
<td>experience and motivation for PI</td>
</tr>
<tr>
<td>creation and attitude to PI</td>
</tr>
<tr>
<td>consumption and attitude to PI</td>
</tr>
<tr>
<td>availability and attitude to PI</td>
</tr>
<tr>
<td>availability and motivation for PI</td>
</tr>
<tr>
<td>consumption, and motivation for PI</td>
</tr>
</tbody>
</table>

Table 6.1 Positive correlations

6.3 Linear Regressions
Linear regressions were used to explore whether the variables of confidence, usage, experience, and availability could be identified as predictors of attitude to PI, and motivation for PI. In particular, the analysis examined which variables were significant predictors of the outcome variables in question, as well as the effect size, or strength of the relationship between the variables. It is important to note that even small effect sizes in educational research can have substantial value at a practical level (Coe et al., 2017; Lipsey et al., 2012).

After establishing that all required assumptions were met (linear relationship and homoscedasticity were checked using visual analysis of scatter plots; multivariate normality was established as the values of the variables of were all within the acceptable range ($±2$) of skewness and kurtosis; little or no multicollinearity was confirmed by exploring the Variance Inflation Factors (VIF), all of which were below 5; and low or no autocorrelation was determined by exploring the durbin-watson statistics, which were between 1.5 and 2.5),
linear regressions (simple and multiple) were conducted in order to identify predictors of attitude to PI, and motivation for PI.

6.3.1 Confidence as a Predictor
A simple linear regression was calculated to predict attitude to PI based on levels of parental computing confidence. The analysis indicated that increased levels of confidence were a significant predictor of higher levels of attitude to PI ($F(1, 528) = 95.894$, $p < 0.001$), with an $f^2 = 0.19$. This can be considered a medium effect size (Selya et al., 2012) and indicates that participants’ attitudes to PI became more positive by 0.285 for each unit increase on the confidence scale (both scales are measured from 1-5).

Levels of confidence were also identified as a significant predictor of higher levels of motivation for PI ($F(1, 517) = 69.217$, $p < .001$), with an $f^2 = 0.133$. This indicates that for each unit increase on the confidence scale, parental levels of motivation increased by 0.265, and is considered a small effect size (Schermelleh-Engel et al., 2003).

6.3.2 Usage as a Predictor
In order to evaluate the impact of the technology usage on attitude to, and motivation for, PI, a two-scale model was used for multiple linear regressions. The model was made up of technology usage for consumption and creation, and a backwards elimination model was used.

In relation to parental attitude, two iterations were conducted, with the second model, which excluded the consumption variable providing the best fit ($F(1, 181) = 7.086$, $p < 0.008$), with an $f^2 = 0.04$, giving a small effect size. This indicates that those parents who use technology for the purposes of creation are more likely to have a positive attitude to PI. However, the type of technology usage did not emerge as a significant predictor for motivation for PI.

6.3.3 Experience as a Predictor
Programming experience as a predictor of attitude to PI and motivation for PI was also explored. In both cases, experience was found to be a significant indicator ($F(1, 491) = 60.145$, $p < .001$ for attitude; $F(1, 486) = 27.694$, $p < .001$ for motivation), with a small effect size ($f^2 = .122$ and $f^2 = .057$ respectively) in each case.

6.3.4 Availability as a Predictor
In order to evaluate the impact of computing availability on attitude to PI, a two-scale model was used for multiple linear regressions. The model consisted of the items relating to the number of devices in the home as well as the quality of the internet; both items were
included in the model as both were shown to positively correlate with the attitude variable. Once again, a backwards elimination model was used. The two-scale model was found to be a significant predictor of attitude to PI (F(2, 518) = 18.250, p < .001), with a small effect size (f² = .071).

As internet quality did not correlate significantly with motivation for PI, this was not included in the availability model for this variable (hence the presence of the ‘N/A’ entries in Table 6.2). A linear regression indicated that the number of devices in the household is a significant predictor of motivation for PI (F(1, 517) = 16.853, p < 0.001) with a small effect size (f² = .033).

Table 6.2 summarises the relationships between the predictor and outcome variables.

<table>
<thead>
<tr>
<th>Predictor Factor</th>
<th>PI Attitude</th>
<th>PI Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confidence</td>
<td>Significant predictor</td>
<td>Significant predictor</td>
</tr>
<tr>
<td></td>
<td>Medium effect</td>
<td>Small effect</td>
</tr>
<tr>
<td>Creative usage of technology</td>
<td>Significant predictor</td>
<td>Not significant predictor</td>
</tr>
<tr>
<td></td>
<td>Small effect</td>
<td></td>
</tr>
<tr>
<td>Programming experience</td>
<td>Significant predictor</td>
<td>Significant predictor</td>
</tr>
<tr>
<td></td>
<td>Small effect</td>
<td>Small effect</td>
</tr>
<tr>
<td>Availability of devices and Internet</td>
<td>Significant predictor</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Small effect</td>
<td></td>
</tr>
<tr>
<td>Availability of Devices</td>
<td>N/A</td>
<td>Significant predictor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Small effect</td>
</tr>
</tbody>
</table>

Table 6.2 Predictive power summary

### 6.4 Limitations of Survey Findings

As the survey aimed to measure psychological constructs that only the respondents had direct access to (i.e., beliefs, intentions, and attitudes), the respondents were asked to self-report on the various factors. Response bias, a widely discussed phenomenon in behavioural and healthcare research where self-reported data are used (Rosenman et al., 2011), was therefore identified as a threat. While acknowledging this limitation, the risk that respondents may respond with a socially acceptable response rather than being truthful was somewhat mitigated by ensuring that the survey was completely anonymous in nature with no identifying information requested (Warner et al., 2011). Another cause of response bias is that individuals may not be able to assess themselves accurately. Care was taken to avoid misunderstandings with scales being clearly labelled and items kept simple with avoidance
of potentially unfamiliar words (Tourangeau et al., 2000). In addition, the survey was pre-tested with five members of the target population with resulting minor changes to language. Given the voluntary nature of the responses to the survey and also the fact that some of the recruitment was done through organisations that could reasonably be said to consist of parents with existing high levels of involvement in their children’s education such as the NPC, questions arise over how representative of general population the sample investigated is. This is mitigated somewhat by the high numbers of responses. However, the gender imbalance of the sample (82% female) is noteworthy and further research is clearly necessary on the role of gender in this study. The seemingly high number of those with a computing qualification (21% compared to 14% of the general population) may be because those more interested in technology may have chosen to respond to the survey. However it may also be at least partially explained by the fact that the data source for the general population is the Central Statistics Office’s (CSO) Labour Force Survey (LFS) which only refers to the highest level of education achieved by an individual and others may have studied computing outside of that definition. Indeed, further analysis of the survey findings during the learner requirements analysis described in Section 8.3.4 found that the reported qualification level varied hugely, from basic computer literacy certification such as the European Computer Driving License (EDCL) right up to PhD level.

It should also be noted that, in the context of this analysis, the absolute level of the various factors (for example ‘confidence’) was not meaningful, with the self-reported scores being investigated as correlates or predictors of other outcomes. As Schwarz et al. (1998) have noted, many of the response bias effects identified in the literature, have a larger effect on mean levels and other characteristics of item distributions than on correlational results.

A further limitation, as this was not an experimental research design, is that any claim for direction of causality is tentative. However, there are demonstrated correlations between the predictor and outcome variables and the causal hypothesis advanced is strongly supported by the literature and the focus group, as well as the linear regression analysis of the survey findings.

6.5 Conclusion

In terms of addressing RQ1, the results of inferential analysis showed that there is a positive correlation between parents’ confidence levels and their attitude to PI. The level of parental
confident was also identified as a significant predictor of higher levels of motivation for PI. Perhaps unsurprisingly, it emerged that parents who have previous programming experience also had a more positive attitude towards PI. When looking at technology use, it was found that parents who use technology for creative purposes are more likely to have a positive attitude to involvement in their children’s CS Education. All of the scales broadly confirmed the factor structures as hypothesized and the findings are generally consistent with the analogous research consulted in the identification of those factors (see Table 4.1). However the finding that the type of usage (creation or consumption) was important was not initially anticipated. These findings provide more clarity around what attitudes and behaviours any supports need to target in order to maximise the impact on both the quantity and quality of PI in CS Education.

Overall, it can be argued that the validity and reliability of the developed scales is sufficient to justify the further investigation into its potential contribution to evidence-based design described in the following chapters. In addition, it can be claimed that the instrument developed can be used in future experimental settings to measure the predictor and outcome variables and establish causation.
7. Design Principles: From Theory to Practice

7.1 Introduction

RQ2 asks what principles should inform the design of interventions to support PI in CS Education. The principles are intended to support educators and researchers by providing evidence-based guidance for exploring design solutions for such interventions. The process for developing these principles is outlined in Figure 7.1 below. This chapter outlines the theoretical basis for the principles and concludes with a first draft. The refinement of this draft through the implementation and evaluation of Design Experiments based on the principles is described in subsequent chapters.

The identification of factors that have an impact on parental attitudes towards PI in CS Education described in Chapters 4, 5 and 6 provides us with a clearer idea of what such interventions should be targeting. Parental computing confidence emerged as a clear predictor of positive attitudes towards and motivation for PI. In addition, other positive predictors were revealed as parents’ programming experience, computing availability, and usage of technology for creative purposes.
A further consideration was that the Design Principles need to support interventions that are, by definition, aiming to have an impact beyond their immediate implementation; their explicit goal is to motivate parents to continue to engage in computing activities with their children in the home. Interventions need to promote autonomy and self-directed learning as it is crucial for participants to take ownership of their learning. The development of the Design Principles therefore started with the premise that any interventions should create opportunities to experience computer programming and look to foster confidence, creativity and further self-sustained CS activity.

While much attention has been given to the rigour of the research methods component of DBR (Anderson & Shattuck, 2012; Barab & Squire, 2004; Cobb et al., 2003; Dede, 2004), Gravemeijer & Bakker (2006) argue that the quality of the design component merits equal consideration. This should be well-considered, and founded on “robust theory about learning and teaching” (Reeves & Orrill, 2006). The process of developing the Design Principles therefore began with a literature review to identify appropriate supporting instructional theories.

The Design Principles have been discussed in previous collaborative papers (Bresnihan et al., 2019a, 2019b). However, the literature review presented in this chapter is solely the researcher’s work.

### 7.2 Literature Review

In theoretical terms much of the discussion of learning within the family has been informed by the insights of constructivist theorists such as Piaget, Vygotsky, and Freire (Mackenzie, 2010). Piaget’s developmental theory, with its belief that in order to appreciate the nature of knowledge, “we must study its formation rather than examining only the end product” (Kamii & Ewing, 1996, p. 260), has helped to shift the way in which learning is understood and evaluated. Piaget argued that the way in which one acquires, or constructs, knowledge is equally, if not more important, than the knowledge attained. Vygotsky had earlier brought a social dimension to this process, particularly with his concept of the “zone of proximal development” (ZPD) which is concerned with how social interaction can help to bridge the gap between a learner’s current and potential levels of cognitive development. He posited that a person’s learning, development, and knowledge are all rooted in the particular social and cultural context in which they exist. The idea of teaching and learning as less of a transmissionist and more of a connected, learner-centred model manifests in an approach
Chapter 7. Design Principles: From Theory to Practice

where teachers are not simply information providers, but facilitators of students’ knowledge construction (Vygotsky, 1980). Freire also articulated the inseparable nature of learning and experience and championed the idea of a learning experience that encourages dialogue between teacher and learner, with each learning from each other, over traditional ‘banking’ systems of education where the teacher ‘deposits’ facts into the learner (Freire, 1996). This dialogic approach to learning is particularly powerful in the context of family learning, with the familiar and shared contact of parent and child providing rich opportunities for talking, negotiating and learning (Tizard & Hughes, 2008).

As PI can clearly be located within situated approaches to learning that acknowledge the importance of socio-cultural issues in learning relationships, the development of the Design Principles can be usefully grounded in such social-constructivist theories. The purpose of this literature review is therefore to identify and understand the nature of social interactions that surround and support family learning and to foreground how to best support such learning in the context of family-based CS Education. It aims to take such theories of learning, where knowledge construction is viewed as a social and cultural process and social interaction is crucial to the learning outcomes, and examine them for their practical pedagogical implications in this context.

7.2.1 Literature Review Process

The literature review process was similar to the previous reviews being iterative and organic in nature. It began by identifying seminal works in the domain of Social-Constructivism. Key thinkers such as Dewey, Freire, Piaget, and Vygotsky were interrogated to establish a deeper understanding of the underlying theories. The next step was to explore how these theories could apply to family learning. Databases previously identified as being relevant to education and technology (ERIC (Education Resources Information Center), ACM Digital Library, IEEE, Science Direct and the academic search engine Google Scholar) were all used and began with general search terms such as: ‘family learning’, ‘intergenerational learning’, ‘community learning’. As the review progressed, key ideas (such as scaffolding, communities of practice, reflection and constructionism) were, in turn, identified through critical reading and subsequently deployed as search terms. “Pearl growing” (Petticrew & Roberts, 2008) and “snowballing” (Ridley, 2012) were again employed.

As previously stated, the literature review aimed to examine the social interactions that surround and support family learning particularly in the context of family-based CS Education. The review therefore began by exploring how social interaction can lead to
learning, particularly in intra- and inter- family contexts (Section 7.2.2). It then moved to consider how best to support and focus such learning (Section 7.2.3) and what form effective learning activities may take (Section 7.2.4), before a final consideration of how such activities can support cognitive development through dialogue and reflection (Section 7.2.5).

7.2.2 Social Interaction and Learning

Piaget’s development theory has contributed to the understanding of learning as a collaborative process. He saw social interactions being useful as individuals can use discussion to operate on each other’s ideas: “above all differentiating the different points of view and introducing between them a reciprocity which is an operational transformation” (Piaget, cited in Rogoff, 1998, p. 685). Although it is arguable whether this conception of individuals using other people’s ideas to advance their own can be described as truly collaborative (Crook, 2018; Matusov, 1996). Piaget also believed that very young children are largely unable to benefit from social influence because their egocentricity means that they would either continue to see things from their own perspective or switch perspectives but not understand why. However, others have suggested that the age at which children learn from social interactions depends on the activities involved (Rogoff, 1998) and the language used (Donaldson, 1978; Tizard & Hughes, 2008). In Vygotskian terms, the social interactions should be within their ZPD and are key to cognitive development.

Dewey’s theory of development through experience was developed concurrently with Vygotsky’s theories (and built on some of the same prior work) and is compatible with it. They both argue that the development of cognition takes place when learners actively participate in shared community endeavours:

The social environment... is truly educative in its effects in the degree in which an individual shares or participates in some conjoint activity. By doing his share in the activity, the individual appropriates the purpose which actuates it, becomes familiar with its methods and its subject matters, acquires needed skill and is saturated with its emotional spirit. (Dewey, 2011, p. 26)

Rogoff, in her research into ‘learning communities’ also argues that cognitive development or learning occurs as a process of “transformation of participation in sociocultural activity” (1998, p. 687).

For the purpose of this research, we are therefore looking to design sociocultural activities that support PI in CS Education that foreground collaboration and dialogue, in particular (1) intra-family collaboration and (2) inter-family collaboration.
Empirical work on the social grounding of cognitive development has documented the varied ways that caregivers guide participation in cultural activities and practices (Gauvain, 2001; Rogoff, 1998). Rogoff’s theory of ‘guided participation’ is particularly relevant to the family context. Inspired by Vygotsky’s ZPD, she describes a form of apprenticeship where learning occurs through ‘guided participation’ in specific cultural activities and cognition is ‘situated’ in specific contexts. By positioning learning within this participation in sociocultural activities she emphasises how individual and cultural processes are interconnected; as people partake in, and contribute to, cultural activities, their involvement brings about changes in both the activities and the participants (Rogoff, 2003). As Rogoff outlines, these interactions “allow children to participate in activities that would be impossible for them alone, using cultural tools that must be adapted to the specific practical activities at hand, and thus passed on to as well as transformed by new members of the community” (1998, p. 682).

Within the family learning context, examples of this type of learning are provided in Tizard and Hughes’ transcripts of parents talking with their children during their everyday lives and play. In these sessions, the children initiated discussions in order to satisfy their curiosity, with parents providing a ‘scaffold’ for their conversation. Makenzie gives examples of normal family activities that create learning: “[e]njoying a book, taking a walk, visiting the Post Office, baking a cake, fixing a puncture and playing a computer game all provide contexts for family learning” (2010, p. 7) and stresses the importance of dialogue in this process.

While Rogoff’s focus is on how parents influence their children's learning through their everyday, informal interaction, Barron (2009) describes how more purposeful intra-family coactivity can also contribute to learning. Such activity gives an opportunity for observation and for spontaneous questions and explanations as well as parents providing support as the “more knowledgeable other” within the child’s ZPD (Vygotsky, 1980).

The relevance of this theory to CS Education is reinforced by the previous review of related interventions (Section 2.6.2) which concluded that there are potential benefits for PI when parents and children engage together in collaborative CS activities. Von Wangenheim et al. (2017) argue that family computing workshops provide an opportunity for families to share ideas, explore computing as a career, and create important time for intergenerational learning. Roque et al. (2015) suggest that learning computing as a family reinforces sharing behaviours and attitudes, adding that “parents can benefit from first-hand engagement with
the design practices of computing and with the practices of supporting their children in computing experiences” (p. 687).

The implications of this for the Design Principles include:

- **Interventions should take the form of coactivity, with families engaging together in collaborative CS activities.**
- **Dialogue about the activity should be supported and encouraged.**

### 7.2.2.2 Inter-family collaboration

The importance of the broader community outside of the family to learning is explored by Lave and Wenger (1991) who also see learning as a social process, characterised by what they term ‘legitimate peripheral participation’. This ‘situated learning’, which takes place in a specific context and a particular social and physical environment, involves the learner becoming a member of a ‘community of practice’ and moving toward full participation in that community. Bers (2007) points out the importance of a shared goal or “joint enterprise” in the development of such communities and adds that workshops are “natural spaces for forming communities of practice in which people engage with each other and with new knowledge and skills by producing artifacts, relationships and ideas” (Bers, 2007, p. 552).

The importance of inviting participants’ input into the development of such communities is emphasised by Summer & Summer (2014). This actively engages families by recognising their existing expertise and building on skills and competencies that they already possess. This draws on Gonzales et al.’s influential concept of ‘funds of knowledge’ which presupposes that “people are competent” (2006, p. x). This idea, that people have knowledge that they have gained through life-experience and that it is possible to harness this knowledge for positive learning experiences, fits comfortably within the social constructivist framework of this study and, more specifically, provides a strong argument for co-creation. Inviting families to contribute to the learning environment through such activities as setting learning goals and choosing topics with other families may work to strengthen inter-family collaboration and dialogue.

Interventions should therefore

- invite participants’ input and recognise their existing knowledge and expertise;
- encourage families to engage with other participating families for help and support.
7.2.3 Structure and scaffolding

While the benefits of social interaction, both within and between families, to learning has been established, there is a danger that this can lead to a lack of clear structure and focus. Constructivist learning environments have been criticised as being unstructured (Baines & Stanley, 2000) and characterised by “a reluctance on the part of many teachers and parents to take direct responsibility for influencing the child's learning and educational development” (Matthews, 2003, pp. 54–55). Such criticisms tend to come from a positivist or behaviourist perspective and be directed at an extreme version of constructivism that involves the complete rejection of that perspective (Kamii & Ewing, 1996). In particular, much of this criticism of constructivism is focussed on it being overly child-directed. This is based on an assumption that it relegates educators to a passive role in the learning environment. Rogoff points out the reductive nature of this argument: “Together, the adult-run and children-run models constitute the one-sided philosophy of instruction in which adults and children are seen as contesting for control with the side that does not have control being passive” (1994, p. 395). Indeed Dewey himself, a noted champion of active participation of students in their own education, rejected this debate as an “extreme Either-Or philosophy” pointing out that “it does not follow[…] that the knowledge and skill of the mature person has no directive value for the experience of the immature” (Dewey, 1986, p. 8).

In practice then, constructivist learning environments can often be highly structured with teachers or facilitators carefully designing and promoting experiences that, in turn, require students to become active participators in the learning process. Bruner’s concept of ‘scaffolding’ is useful here. Taking Vygotsky’s ZPD theory, where we can learn more in the presence of a knowledgeable other person, as a starting point, Bruner argues that when learners encounter new concepts they need purposeful meaningful interaction with a skilled instructor or more proficient peers. At the early stage, they are reliant on that active support, but as they become more independent in their thinking and gain competence and knowledge, the support can be gradually removed (Wood et al., 1976). Rather than directly presenting or providing content, the instructor supports or ‘scaffolds’ the learning experience by providing the information and resources necessary for the learner to construct or discover it either individually or collaboratively.

However, while ZPD and scaffolding are often conflated, they are not equivalent. ZPD is a broader and more flexible concept which includes the contribution of the novice to the shared endeavour of learning, something that is often overlooked in discussions of
scaffolding. This idea is at the heart of the community-of-learners model (Brown & Campione, 2002; Newman et al., 1989; Rogoff, 1994; Tharp & Gallimore, 1991) which emphasises the active and participatory nature of all parties in the learning process. Rogoff captures this idea well:

In a community of learners, both mature members of the community and less mature members are considered as active; no role has all the responsibility for knowing or directing, and no role is by definition passive. Children and adults together are active in structuring shared endeavors... (1994, p. 213).

Structure and purpose are clearly important in this model; but it is conversational in nature with all parties contributing to the direction. Such contributions may vary depending on the nature and context of the learning.

From the discussion above, the following implications are relevant to the formation of the principles:

- **Interventions should consist of clearly structured activities.**
- **Participants should be given the opportunity to become progressively more active in planning and structuring the activities.**

These conclusions necessitate a closer look at what form such structured activity should take.

### 7.2.4 Creativity and Constructionism

A family-learning activity will often result in a product that enhances the community; traditionally that may have been a musical or theatrical production, a festival or storytelling event. Makenzie (2010) conducted extensive questionnaires, interviews and field visits exploring family learning in Scotland. A key theme that emerged was the power of the arts to provide contexts in which families can experience personal and social transformation. She found that bringing families together to prepare a shared creative output such as drama, dance or music developed a sense of connectedness as well as providing fun, promoting inclusivity and building self-esteem.

Learning through participation in sociocultural activities does not come from copying what is already invented or what is available in the existing thinking or knowledge of other participants. Rather it is a creative process. Leont’ev, a disciple of Vygotsky, stressed the transformational power of collaborative participation in cultural practices or activities. These ‘activities’ are characterised as purposeful, transformative, and developing interaction between actors (“subjects”) and the world (“objects”) (Leont’ev, 1978).
Alongside the power of creative activities lies the importance of their outputs. Papert’s theory of Constructionism argues that learners can actively create, interpret, and reorganize knowledge in a particularly effective manner through the construction of a meaningful tangible artefact (Papert, 1980). This argument has had a powerful legacy in the sphere of CS Education. As well as obvious influences on the development of accessible programming tools for children such as Logo and Scratch, Lye and Koh’s (2014) review of interventions to teaching coding and computational thinking concluded that Constructionism has gained wide acceptance as a classroom approach to teach children computing and usually reports positive outcomes.

The interventions should then

- involve participants working towards the creation of a meaningful tangible artefact;
- formalise the sharing and celebration of activity outcomes between families.

### 7.2.5 Reflection

Finally, we need to explore how participation in these activities can effectively lead to development. For Dewey, reflection is “the thread that makes the continuity of learning possible” (Rodgers, 2002). He understood reflection as a process of making meaning through the learner connecting their current experience with past experiences and ideas in a systematic fashion, so as to develop a deeper understanding. Freire (1996) also placed importance on people’s consciousness of learning and change aided by reflection. While systematic reflection is undoubtedly a challenge for young children, Donaldson argues strongly that the benefits of reflection are available to them, seeing it as a vehicle for developing ‘disembedded’ thought from the concrete to the abstract. (1978, pp. 76–79). This can be enabled through more dialogue with children, in order to maximise what they are learning from the activity (Tizard, 1975, p. 13).

Interestingly, for the purposes of this study, Dewey also proposed that ideally reflection be undertaken in interaction with others (1997). Rodgers identifies three advantages of collaborative reflection: (1) affirmation of the value of one’s experience; (2) seeing things “newly”; and (3) support to engage in the process of inquiry (Rodgers, 2002). Facilitating collaborative reflection can also demonstrate the value of a wider community by providing greater clarity to issues than can be individually perceived in order to strengthen the connection between families (Rearick & Feldman, 1999). The importance of reflection in turning experiences into learning means that:
• interventions should be structured to include time and space for ongoing dialogue about what is being learned;
• time should be reserved for collaborative reflection at the end of the learning experience.

7.3 Conclusions and Draft Design Principles

The Literature Review took, as a starting point, the need for the Design Principles to address the previously identified factors that potentially have an impact on parental attitudes towards and motivation for PI in CS Education. They should look to support the design of interventions which increase parents’ competence and confidence with digital skills and tools as they endeavour to support their children’s learning. Participants need to be encouraged to take ownership of their learning thereby increasing their confidence to pursue similar activities in the future. Constructivism, with its emphasis on active self-directed learning, and in particular Social-Constructivism with its awareness of the importance of social interaction and collaboration for learning, were therefore identified as an appropriate theoretical base. The Design Principles are an attempt to bridge the gap between such theory and local or specific interventions and practices (Bell et al., 2004) through the extraction of practical pedagogical implications from the theory.

The review of the literature supported the adoption of a social-constructivist based environment, with scaffolding and reflection activities. Within this framework the Design Principles outlined in Table 7.1 below were identified:
### Design Principles: From Theory to Practice

<table>
<thead>
<tr>
<th>DP</th>
<th>Principle</th>
<th>Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1</td>
<td>The interventions should be collaborative within families.</td>
<td>Social-constructivism</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Family learning</td>
</tr>
<tr>
<td>DP2</td>
<td>The interventions must bring multiple families together to encourage</td>
<td>Communities of Practice</td>
</tr>
<tr>
<td></td>
<td>inter-family support and communication.</td>
<td>Communities of Learning</td>
</tr>
<tr>
<td>DP3</td>
<td>The interventions should consist of <em>structured</em> activities.</td>
<td>Scaffolding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guided Participation</td>
</tr>
<tr>
<td>DP4</td>
<td>Participants’ input should be invited, and their existing knowledge</td>
<td>‘Funds of Knowledge’</td>
</tr>
<tr>
<td></td>
<td>and expertise recognised. They should be given the opportunity to</td>
<td>Scaffolding</td>
</tr>
<tr>
<td></td>
<td>become more active in planning and structuring the activities as</td>
<td>Communities of learning</td>
</tr>
<tr>
<td></td>
<td>the intervention progresses.</td>
<td></td>
</tr>
<tr>
<td>DP5</td>
<td>The interventions should use computers as creative tools and lead to</td>
<td>Constructionism</td>
</tr>
<tr>
<td></td>
<td>the making of a <em>meaningful artefact</em>.</td>
<td>Family learning</td>
</tr>
<tr>
<td>DP6</td>
<td>The outcomes of the intervention should be celebrated and shared.</td>
<td>Constructionism</td>
</tr>
<tr>
<td>DP7</td>
<td>The interventions should be structured to include ongoing dialogue</td>
<td>Reflection</td>
</tr>
<tr>
<td></td>
<td>about what is being learned. Time should be reserved for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>collaborative reflection to complete the learning experience.</td>
<td></td>
</tr>
<tr>
<td>DP8</td>
<td>The interventions should encourage the pursuit of further activity,</td>
<td>Communities of practice</td>
</tr>
<tr>
<td></td>
<td>as a family unit or along with other families.</td>
<td>Communities of learning</td>
</tr>
</tbody>
</table>

**Table 7.1 Draft Design Principles**

The next step in the research was to conduct a number of Design Experiments to test the efficacy of these principles in practice. Accordingly, the following chapters describe the design, implementation and evaluation of interventions based on these principles.
8. Design Experiments: Context

8.1 Introduction
While the previous chapters established a theoretical basis for the Design Principles, the Design Experiments aimed to test and refine the principles and explore their effectiveness in bridging the gap between such theory and local or specific interventions and practices (Bell et al., 2004). Fishman et al. (2004) identify the challenge faced by education research in evaluating such interventions due to the influence of such local contextual variables in shaping the desirability, practicality, and effectiveness of their designs. Indeed, the complexity of these variables present in effective interventions raises questions over the possibility of longitudinally differentiating a design from, what Dede (2004) terms, its ‘conditions for success’. Despite this, as Barab points out, the “messiness of real-world practice must be recognized, understood, and integrated as part of theoretical claims if the claims are to have real world explanatory value” (2014, p. 153). Dede describes two methods by which the DBR community can deal with this problem (1) by expanding the design to include the conditions for success and (2) by interweaving complementary DBR studies to further consider such conditions. Before this can be done, however, it is necessary to identify these variables and the challenges that they provide, this chapter therefore describes the context of the delivery of the Design Experiments and contains an analysis of the specific target-population’s requirements.

The Design Challenges outlined in Section 8.2 below have been discussed in previous collaborative papers, as has the learner requirements analysis (Bresnihan et al., 2019b, 2020). The learner requirements analysis was the sole work of the researcher; the Design Challenges were identified collaboratively by the project team. The discussion of both here greatly expands on this previous work.

8.2 Delivery Context
In December 2017 the researcher was awarded 12-month funding from Science Foundation Ireland (SFI) to design, develop and evaluate family creative-coding workshop models with the aim of encouraging and supporting PI in CS Education. The target population was families that included primary-school children (age 4-13) in Ireland. The project, known as OurKidsCode, began in 2018 with the design and evaluation of a model for one-off
workshops for these families. These consist of structured creative activities allowing families to learn together and encouraging them to continue to develop their knowledge. The workshops are focused on initiating engagement and building confidence and are supplemented by online information and support. Further funding (12 months) was awarded for the development, in 2019, of a four-part programme, run over consecutive weeks. This built on the previous one-off workshop and was designed to foster self-reliance and build self-sustaining communities of learning by increasing competence, and skills in accessing knowledge and using materials. A third tranche of funding (24 months) was provided for the national roll-out during 2020 and 2021 of the workshops developed. The plan involved delivering the workshops to families in informal settings by training existing parental and education networks in their facilitation, primarily the National Parents Council (Primary) (NPC) training staff, coding club (e.g. CoderDojo) volunteer mentors, and primary-school teachers. Professional development workshops to train the facilitators were planned to run on demand, with facilitators self-selecting to attend workshops which were to be scheduled on weekends or evenings during each academic year.

Prior to the design of the one-off workshops, the anticipated modes of delivery were analysed and a number of contextual challenges were identified. These are set out below in Table 8.1. As recommended by Dede (2004), the design process was expanded to include providing solutions to these design challenges (DCs).

<table>
<thead>
<tr>
<th>DC</th>
<th>Context</th>
<th>Design Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC1</td>
<td>The workshops will be delivered throughout Ireland by a variety of facilitators, primarily the NPC training staff, coding club mentors and teachers but also other interested parties.</td>
<td>The diversity of backgrounds and experiences of these facilitators means that the workshops must not require the facilitators to have extensive technical knowledge. A need for support materials for the organisation and running of the workshops was also identified, both to assist facilitators, and to help participating families solve problems as they encounter them in the tasks.</td>
</tr>
<tr>
<td>DC2</td>
<td>The NPC trainers are typically contacted by schools to deliver training for parents in an after-school context.</td>
<td>The OurKidsCode workshops must therefore be designed to be deliverable in this same way. Each workshop must be designed to fit into the 60-90 minutes that are usually available for after-school activities.</td>
</tr>
<tr>
<td>DC3</td>
<td>The typical physical space available is a school classroom.</td>
<td>The constructionist nature of the workshops means that they involve groups engaging in physical activities. So that neither the facilitators nor the available physical spaces are over-stretched, 20 participants or at most 5-6 families, is the maximum number of participants.</td>
</tr>
</tbody>
</table>
The workshop activities should be suitable for continuation in the home. The necessary materials for activities need to be made available to families.

Table 8.1 Delivery design challenges

8.3 Learner Requirements

An analysis of the learner requirements was undertaken to support the development of the interventions within the delivery context described above. The responses to the parent questionnaire described in Chapter 5 provided an opportunity to collect relevant local data. As the workshops were directed at families rather than parents alone, the child perspective was also considered to be of interest and therefore a complementary survey was conducted aimed at primary-aged children (4-13). This process and its findings are described in the following sections.

8.3.1 Questionnaire Design

The design and development of the parents’ survey has been described in detail in Chapters 4 and 5. While the focus of the research described here is the parent learners, the design of the child survey will be briefly described. This survey was designed to complement the parents’ survey with the aim of establishing what kind of support (if any) children were currently receiving for their CS Education and, in particular, what role their parents were playing in this. There was also interest in their computing behaviours and attitudes.

The difficulties of conducting research with child participants is well documented (Borgers et al., 2000; Christensen & James, 2000; Punch, 2002; J. Scott, 2008). The ethical issues involved have been previous discussed in Section 3.8. In addition, measurable differences between adults and children exist in the range of vocabularies and the understanding of words, experience in the world, and attention spans (Punch, 2002). Both the addition of some further items to the parent questionnaire and its adaptation to make it more suitable for children was therefore undertaken. However, it is acknowledged, that limitations still exist as to the reliability of the responses, particularly for those in the 4-7 age group (Borgers et al., 2000).

The survey included 19 items that aimed to investigate: children’s computing confidence (six items); usage (three items); experience (two items); and availability (four items). It also contained 15 items relating to parental involvement: PI in CS activities (seven items); and children’s attitudes towards PI in CS Education (eight items). In addition, the survey included three items that requested demographic information and a final question to gauge their
interest in family coding workshops. The items were presented in mixed order. The full instrument is contained in Appendix D.

Where possible, items for scales were taken from the parents’ survey or were adapted from existing, validated instruments (Table 8.2).

<table>
<thead>
<tr>
<th>Category</th>
<th>Factors</th>
<th>Overview</th>
<th>Scales Adapted</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-computing</td>
<td>Demographics</td>
<td>Gender, Age, School class</td>
<td>Generic Markers used across instruments designed by researcher’s Research Centre.</td>
</tr>
<tr>
<td>Computing behaviours and attitudes</td>
<td>Confidence</td>
<td>Ease and enjoyment of computer use</td>
<td>Cutts et al. (2018); Vannatta &amp; Banister (2008)</td>
</tr>
<tr>
<td></td>
<td>Usage</td>
<td>Time, purpose, parental restrictions</td>
<td>Hayward et al. (2002)</td>
</tr>
<tr>
<td></td>
<td>Experience</td>
<td>Learning method, Learning Source</td>
<td>Strong et al. (2017)</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
<td>Devices</td>
<td>Hayward et al. (2002)</td>
</tr>
<tr>
<td>Parental Involvement</td>
<td>Activities</td>
<td>What activities are Parents involved with?</td>
<td>Aesaert et al. (2015)</td>
</tr>
<tr>
<td></td>
<td>Attitude</td>
<td>How do children feel about the involvement?</td>
<td>Aesaert et al. (2015)</td>
</tr>
<tr>
<td></td>
<td>Interest</td>
<td>Whether the child would be interested in family computing workshops</td>
<td></td>
</tr>
</tbody>
</table>

Table 8.2 Child survey item development

Once developed, the survey was pre-tested with four children of the target age-range (Tourangeau et al., 2000). This process did not lead to any substantive changes, however, some of the language was further changed to be more ‘child-friendly’.

8.3.2 Survey Distribution

As previously described in Section 5.3, the parent questionnaires were distributed online in July and August 2018 to approximately 10,000 parents of primary school children across Ireland. The parents were also provided with a link to the child questionnaire with a request that they ask their children to complete it. Both parental consent and child assent were required to access the child questionnaire. The surveys were completed by n=1228 parent respondents and n=405 child respondents.

8.3.3 Data Analysis and Validation Measures

Chapters 5 and 6 used inferential statistics to analyse the findings of the parent survey with regard to the exploration of RQ1; specifically, to identify what factors have an impact on
parental attitudes towards PI in CS Education. How the validity of the parent survey was established was discussed in Section 5.4. In the context of the learner requirements analysis, further analysis of the data using descriptive statistics was undertaken in order to examine the requirements of parent learners. It should therefore be noted that the sampling and response limitations discussed in Section 6.4 are more impactful here as absolute values rather than correlations or predictors are being discussed. These limitations also apply to the child survey.

In the case of the child survey, for the purposes of the learner requirements analysis, the determination of the extent to which the items in the scales represented an underlying construct was not relevant, rather the interest lay in providing counts or frequencies useful for developing trends or building profiles (Oppenheim, 1966; Rose & Sullivan, 1993). For this reason, analysis using univariate descriptive measures was deemed appropriate.

Findings are therefore presented with the further caveat that descriptive statistics are limited in their generalisability, allowing you to only make summations about the people or objects that you have actually measured. In this case descriptive measures were used to build a picture of the learners, bringing together profiling variables related to age, experience, attitude, skills and knowledge.

8.3.4 Learner Requirements Analysis Findings
8.3.4.1 Demographics
The questionnaires were completed by 1,228 parents and 405 children. As previously reported (Section 5.3), the parent respondents were overwhelming female (82%). The child respondents were more evenly distributed but included slightly more males (55%) than females (45%) (Figure 8.1).

![Figure 8.1 Gender breakdown](image)
Only three parents were under the age of 25, with almost 90% between the ages of 36 and 55 (Figure 5.1). The child respondents ranged in age from 5-14 and were spread across all primary school years (Figure 8.2).

![Figure 8.2 Age and school year of child respondents](image)

About 20% of the adults reported living in cites and parents from every county in Ireland were represented. When it comes to describing their main role, 71% of parents were working for payment or profit and 21% were looking after home/family. Other roles included carers, students, unemployed, retired, and those unable to work due to illness or disability. About 2% reported a combination of roles, e.g. part-time work and carer.

### 8.3.4.2 Parent Questionnaire

The survey found that parent respondents clearly recognise the importance of computing, with 95% of them agreeing or strongly agreeing that all children should have an opportunity to learn about computing in primary school (Figure 8.3).

![Figure 8.3: Computing in primary schools](image)
Parents also realise that they have a role to play in this and they want to actively engage with their children, with 68% agreeing or strongly agreeing that learning new things about computers that they can use with their families is important to them (Figure 8.4) and 77% agreeing or strongly agreeing that they would like to spend time with their child when they are learning about computers (Figure 8.5). These findings clearly supported the rationale for the interventions and, in particular, DP1 - that the interventions should be collaborative within families.

The parents have multiple motivations for this, with 84% reporting that they’d like to help their child understand what computer programming does. They also overwhelmingly agreed that it is important to teach their child about the role computers play in society (94%) and that they would like to be able to help their child decide if they would like to be a
Computer Scientist or work in technology in the future (84%). Despite this only 15% of respondents regularly plan activities in which they use computers with their children (Figure 8.6).

![Figure 8.6: Planning computing activities with children](image)

Regarding experience, as previously discussed quite a high number of parents, 21%, reported that they have a qualification in computing, however the level ranged from basic computer literacy certification such as the European Computer Driving License (EDCL) right up to PhD level. This could be a result of the self-selecting nature of the sample, as those more interested in technology may have chosen to answer the questionnaire. On the other hand, 68% have never tried to program with another 7% reporting that they have tried but not succeeded (Figure 8.7).

![Figure 8.7: Level of programming](image)
The findings for the question concerning what they used computing devices for at home were analysed guided by the framework of the two-factors identified from the usage data in Section 5.4, *consumption* and *creation*. Passive or ‘consuming’ activities such as browsing the internet, watching videos, listening to music, playing games and shopping were each being carried out by over 70% of respondents while more creative activities such as desktop publishing, website development, media creation, programming and robotics were undertaken by less than 20%. Figure 8.8 shows the percentage of respondents reporting each activity. In the case of the more creative activities, it was almost entirely the same set of respondents who reported partaking in them.

**Figure 8.8: Parents’ usage**

Despite this, most reported confidence in their use of computers with 67% agreeing that they are confident in their ability to troubleshoot when problems arise and 77% that they are confident when trying to learn new things.

8.3.4.3 Child Survey

The child respondents, similarly to their parents, mostly use computers as consumers rather than creators. Playing games is the most popular activity followed by viewing videos, listening to music, browsing the Internet and using Educational Apps. Only 22% report that
they have engaged in programming with numbers for robotics or electronics (5%) and making websites (1.7%) even lower (Figure 8.9).

![What do you use computers for?](image)

Figure 8.9: Children’s usage

It is also clear from the child survey that many parents are already taking a lead in their children’s computing education: they monitor usage with 94% of children saying that their parents limit their screen time and 83% saying their parents decide what activities they do on the computer. The children also report ‘often’ or ‘always’ (66%) turning to their parents for technical support.

Interestingly, when asked where they learned about computers, while 55% reported they learned at school, this was followed very closely by the 53% who learned at home. In contrast only 17% reported learning at computer clubs or after-school classes and 20% have never learned (Figure 8.10).
Figure 8.10: Where children have learned about computers

Of particular relevance to this study was the finding that, when asked who has helped them learn, more children identified a parent or guardian (67%) than any other category including teachers (58%), Coderdojo or other computer-club mentors (23%). As well as parents, children also identified siblings (23%) and extended family (12%) as sources of help providing further evidence of the importance of the family in this role (Figure 8.11).

Figure 8.11: Who helped children learn about computers

Furthermore, children like showing their parents things they make on the computer (68%) and generally enjoy spending time on computers with their parents. However, when asked what they did with their parents, the responses once again show a pattern of mostly passive
consumption of media. While parents spend time with their children searching for information on the Internet, listening to music or watching videos, they do not generally make websites, program or do robotics or electronics. The exception to this, is their involvement when their children are working on making projects or presentations (Figure 8.12). As this is often something that is being done as school homework, this could be a positive indication that parents will get involved in school-related computing activities.

8.3.5 Discussion

While recognising the limitations of the sample (most notably its self-selected nature and the potential unreliability of the child responses), the findings provide evidence that, as far as the children are concerned, parents are already involved in helping them acquire computing skills. However, parents seem to underestimate their existing input and are keen to take on a more active role. While their current involvement is mostly with helping their children consume technology and to do so in a safe and controlled way, the exception seems to be when the children need to use technology to create projects and presentations. This could be because this activity is often undertaken for school homework rather than purely for fun or leisure.

The requirements analysis therefore concluded that, while parent and child respondents are comfortable with using computers for more passive activities, they have not generally engaged with more creative computing activities such as programming, media creation, or physical computing. However, they did report a good level of confidence in their ability to
learn new things and expressed a clear interest in learning more creative applications of computing with their families.

This evidence further supported the draft Design Principles, in particular that interventions take the form of creative computing workshops, be collaborative in families and designed to increase confidence. It also provided evidence that families are ready and able to benefit from such interventions.

8.4 Chapter Summary

The importance of context to DBR studies has been previously discussed (Section 3.4.2). Accordingly, this Chapter set out the delivery context of the Design Experiments and identified any arising Design Challenges (Table 8.1). The Chapter continued by describing the learner requirements analysis which used two surveys (one parent, one child) to explore the needs of the target population of families with children in primary schools in Ireland.

A consideration of these requirements, along with the identification of some of the challenges involved in delivery, further informed the design of a workshop model to support parents who feel they lack the skills and knowledge to integrate technology into their children’s learning activities, as well as encouraging and enabling parents to learn and develop their own involvement with creative computing by increasing their confidence and knowledge. This design is outlined in the following chapter.
9. Design Experiments: Design

9.1 Introduction

In order to evaluate the Design Principles, a number of exploratory Design Experiments were designed in accordance with these principles, then implemented and evaluated (Figure 9.1) within the delivery context described in the previous chapter. These began with one-off workshops, which were developed and deployed in various contexts. These workshops, were iteratively implemented, evaluated, and refined in order to explore the validity of the Design Principles in a naturalistic setting. Subsequent to this, as part of the refinement process, a four-part workshop programme, utilising the same model, was developed and evaluated. In this way, each new application served to extend the theory as “its specific characteristics [were] situated in local dynamic” (Barab & Squire, 2004) with local impact being an important component of the validation process. In addition, a complementary study, focusing on the facilitation of the interventions, which emerged during the exploratory studies as a key condition of success, was also conducted and is described in Section 10.5.

Figure 9.1 Design Experiments overview

This chapter describes the initial design process for the interventions. This began by taking the related work identified in Section 2.6.2 and subjecting it to further analysis to ascertain whether the design of such similar activities could contribute towards achieving the objectives of the interventions. As DP3 had identified the importance of structure in the activities, the development of a generic activity model to support the design of the interventions is described in Section 9.3. How this activity model can be operationalised in
local contexts is then illustrated through a description of a sample workshop. Chapter 10 goes on to describe the implementation, evaluation and refinement process.

The design of the workshops and the development of support materials was a collaborative process and has been discussed in previous collaborative papers (Bresnihan et al., 2019a, 2019b). This collaborative work is described in an expanded form in Sections 9.3 and 9.4. The review of related work in the following section was completed solely by the researcher.

9.2 Related Work: Intervention Design Analysis
A literature search was undertaken in September 2018 to identify work describing interventions aimed at both parents and children in the broad area of CS Education, in order to identify possible specific design features which might inform the experiments’ design. The papers that were included in this analysis were found through a search in the educational and technology databases such as ERIC, ACM Digital Library, IEEE, Science Direct and the academic search engine Google Scholar, as well as the references in the peer-reviewed papers discussed earlier in Section 2.6.2. Initially, the analysis was planned to be limited to peer-reviewed papers published in high-impact journals and conference proceedings (or by notable STEM or STEM-related educational organisations) that specifically focus on different kinds of parental engagement with children’s CS learning in or out of school. However, the limited results of this search, and the fact that the interest in these studies was in the design of the intervention rather than its research design or outcomes, caused an expansion of the criteria to include reports and websites. Despite this only eight interventions were identified, further confirming a gap in both research and practice in this area.

The findings of the review are summarised in Table 9.1. The interventions that were chosen targeted either families or parent-child dyads (note, Project Interactions (Bers, 2007) actually conducted most of its workshops with children only, with the family-work based at home between sessions). Both Constructivist and Behaviourist learning approaches were used. Behaviourist approaches involved the use of presentations followed by step-by-step instructions towards a fixed task. Constructivist approaches were more learner-led with facilitators providing support and guidance. The interventions were both single session and multi-session with the shortest being a single 90 minute session (Sadka & Zuckerman, 2017) and the longest being three one-hour sessions a day over five days (Lin & Liu, 2012). The use of robotics and physical computing were popular, with this approach being used in six out of the eight interventions with the other two using programming alone.
The analysis identified three of these interventions, MIT’s Family Creative Learning programme (Roque et al., 2016), Project Interactions (Bers, 2007), and Brahm’s museum-based maker workshops (2014) to be of particular interest as their learning approaches were in line with the draft Design Principles. They are therefore discussed in more detail below.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>Participants</th>
<th>Child Age</th>
<th>Duration</th>
<th>Technology</th>
<th>Setting</th>
<th>Learning Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family Creative Learning (Roque et al., 2016)</td>
<td>Families (n=24 learners)</td>
<td>7-12</td>
<td>5 x 2 hrs</td>
<td>Scratch &amp; Makey Makey</td>
<td>Community Centres</td>
<td>Constructionist</td>
</tr>
<tr>
<td>Project Interactions (Bers, 2007)</td>
<td>Mixed (Families / Child present with family support at home) (n=132 learners)</td>
<td>4-7</td>
<td>5 x 2.5 hrs</td>
<td>Robotics: Lego Mindstorms and Robolab</td>
<td>Various &amp; Home</td>
<td>Constructionist; Community of Practice</td>
</tr>
<tr>
<td>Brahms (2014)</td>
<td>Families (n=5 families)</td>
<td>4-10</td>
<td>not detailed</td>
<td>Sewing, Electronics,</td>
<td>Museum Makeshop</td>
<td>Constructionist; Community of Practice</td>
</tr>
<tr>
<td>Family Code Night (Pearce &amp; Borba, 2017)</td>
<td>Families (n=unknown)</td>
<td>5-11</td>
<td>95 mins</td>
<td>Code.org</td>
<td>Various</td>
<td>Behaviourist (Step-by-step instructions, task, feedback)</td>
</tr>
<tr>
<td>Compuatação na Escola (von Wangenhein et al., 2017)</td>
<td>Parent/Child Pairs (n=unknown)</td>
<td>6-13</td>
<td>3.5 hrs</td>
<td>Robotics: Arduino, Snap/Scratch</td>
<td>Not detailed</td>
<td>Behaviourist (Step-by-step instructions, task, feedback)</td>
</tr>
<tr>
<td>Lin &amp; Liu (2012)</td>
<td>Parent/Child Pairs (n=6 learners)</td>
<td>9-10</td>
<td>15 x 1 hr</td>
<td>Programming in MSWLogo</td>
<td>5-day Computer Camp</td>
<td>Constructivist (Task-based learning)</td>
</tr>
<tr>
<td>Sadka and Zuckerman (2017)</td>
<td>Families (n=8 families)</td>
<td>8-12</td>
<td>90 mins</td>
<td>Automata-building with paper circuits kit</td>
<td>Home</td>
<td>Scaffolding</td>
</tr>
<tr>
<td>Cuellar et al. (2013)</td>
<td>Parent/Child Pairs (n=6 pairs)</td>
<td>not detailed</td>
<td>4 x 2 hrs</td>
<td>Robotics LEGO NXT 2.0</td>
<td>not detailed</td>
<td>Not detailed</td>
</tr>
</tbody>
</table>

Table 9.1 Design of related work

MIT’s Family Creative Learning programme engages families in constructionist learning experiences in computing (Roque, 2020; Roque et al., 2016). The model consists of five weekly two-hour workshops. The families used Scratch and the Makey Makey to complete.
a project which they then showcased to their friends and families. Each workshop had the same structure, beginning with a shared meal (Eat), followed by the children and parents meeting separately and facilitators checking in with them (Meet), the families then worked on their projects (Make), and finally they would share their progress with other families (Share). This work is an interesting illustration of the kind of structured collaborative learning identified in the draft Design Principles. Other relevant findings included the positive impact of creating across digital and physical materials and further confirmation of the effectiveness of providing opportunities for sharing and celebrating the families’ achievements.

Bers characterises the family workshops developed in Project InterActions as “a multi-generational community of practice that follows a constructionist pedagogy of teaching and learning” (2007, p. 539). Parents together with their young children (aged 4-7) worked on robotics projects. Out of six Design Experiments, only two involved the parents and children being co-present at the five two-hour workshops. In the other four only the children attended, and the parents helped out at home. The first two workshops taught the basics of robotics technology using the Lego Mindstorms robotics kit and the Robolab programming language. During the following two workshops, the families worked on a project which they then shared with each other and invited guests. The families were expected to work at home between sessions and were given a resource book and a tech-support hot-line to support that. Bers was particularly concerned to build a community of practice (an aim shared by the Design Principles here) and, to this end, the design explicitly supported the idea of legitimate peripheral participation. This project raised the importance of a careful consideration of the different roles that family members can play and an awareness that participants bring different skillsets and different levels of mastery.

Brahms’ exploration of family participation in a museum-based maker space also relies heavily on Lave and Wenger’s model of the learning trajectories of individuals as they move from peripheral participation as a “newcomer,” towards becoming members of a community of practice. She describes families as “a distributed learning system, who often use designed tools and environments as contexts for sharing, rehearsing, negotiating and developing family members’ relative areas of interest and expertise with regard to content and participation” (2014, p. 41). Once again this points to the importance of paying attention to the roles participants play. In addition, her identification of the maker community learning practice of seeking out resources as a valuable tool in generating self-sustainability is useful here. This practice, often enacted through online searches and social media, as well as
through local community resources, involves a recognition of the distributed nature of learning and the sharing and seeking out knowledge and skills.

9.3 The Activity Model

The draft Design Principles pointed to the importance of structured collaborative learning for the design of the workshops. While most of the reports of the interventions described in the previous section did not provide detail on their structures, both Family Creative Learning (Roque et al., 2016) and Project Interactions (Bers, 2007) provided some guidance. In addition the Bridge 21 model, a team-based, technology-mediated learning model shown to be a pragmatic model for effective twenty-first-century learning (Lawlor et al., 2018) was considered as the researcher had a previous successful experience adapting it for use with teachers (Oldham et al., 2018). In particular the Bridge 21 activity model (Figure 9.2) provided an example of the kind of clear and consistent workshop structure that could assist in keeping families on track (Byrne et al., 2019).

![Figure 9.2: Bridge 21 activity model (Byrne et al., 2019)](image)

Following a consideration of how elements of these models could be adapted to better implement the draft Design Principles, an activity model for the workshops was developed. Table 9.2 lists the workshop phases and notes how each addresses relevant principles (this is preceded by a restatement of the draft Design Principles from Section 7.3 for the reader’s convenience).
**DRAFT DESIGN PRINCIPLES**

**DP1:** The interventions should be collaborative within families.

**DP2:** The interventions must bring multiple families together to encourage inter-family support and communication.

**DP3:** The interventions should consist of structured activities.

**DP4:** Participants’ input should be invited, and their existing knowledge and expertise recognised. They should be given the opportunity to become more active in planning and structuring the activities as the intervention progresses.

**DP5:** The interventions should use computers as creative tools and lead to the making of a meaningful artefact.

**DP6:** The outcomes of the intervention should be celebrated and shared.

**DP7:** The interventions should be structured to include ongoing dialogue about what is being learned. Time should be reserved for collaborative reflection to complete the learning experience.

**DP8:** The interventions should encourage the pursuit of further activity, as a family unit or along with other families.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Rationale and Relevant Design Principle [DP]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup</td>
<td>The physical environment is set up to enable the rest of the workshop. The facilitator makes refreshments available to the participants, distributes materials, and helps ensure the equipment is working.</td>
<td>Debugging issues such as wi-fi connectivity in this phase avoids interfering with the workshop activities. Meanwhile participants begin to talk casually over refreshments [DP2, DP4].</td>
</tr>
<tr>
<td>Introduction</td>
<td>The facilitator briefly explains the workshop model to ground the families.</td>
<td>This sets the scene and helps focus the participants on the process as well as the content [DP3, DP7].</td>
</tr>
<tr>
<td>Icebreaker</td>
<td>All participants take part in an ‘unplugged’ icebreaker activity specific to the creative activity planned for the session. These activities are physical (participants stand up and move around) and both intra- and inter-family in nature.</td>
<td>This phase introduces the creative task and allows families to be more at-ease with each other, thus facilitating peer assistance during the next phase. [DP1, DP2, DP5]</td>
</tr>
<tr>
<td>Create</td>
<td>A creative technical challenge is given, forming the main part of the workshop. The challenges combine coding and ‘making’ activities and are designed to encourage family members to take on different roles during the completion of the challenge.</td>
<td>Families are encouraged to collaborate both within and between family groups, and to take on varying roles as they work on the challenges. [DP1, DP2, DP3, DP4, DP5]</td>
</tr>
<tr>
<td>Share</td>
<td>Families share their creations in a structured way (a tournament or showcase)</td>
<td>Bringing the families together at the end gives a sense of achievement and fulfilment [DP2, DP5, DP6]</td>
</tr>
<tr>
<td>Reflect</td>
<td>All participants sit in a circle and share what they have enjoyed and learned, encouraging discussion of future plans. Participants are provided with OurKidsCode Cards and materials for another of the workshops to complete at home.</td>
<td>Improves the learning by offering an opportunity to say out loud what was learnt and evaluate strengths and weaknesses. Setting agenda for further work and making commitment for future engagement is a part of this phase. [DP7, DP8]</td>
</tr>
</tbody>
</table>

Table 9.2 The Activity Model: Workshop phases and their rationale
The educational designs are created to support the cognitive phenomena under study (e.g., scaffolding metacognitive reflection through the ‘Share’ and ‘Reflect’ phases). This model was used for both the one-off workshops and the four-part model.

9.4 The One-off Workshop

Three different workshops were developed along with support materials. Each workshop follows the activity model, with workshop-specific content being provided for the ‘Icebreaker’, ‘Create’ and ‘Share’ phases. A facilitator trained by the project team guides the families through the workshops. Section 9.4.1 contains a description of a typical OurKidsCode workshop providing an illustration for how the activity model works in practice. This workshop sets families the challenge of constructing a dance mat using the Makey Makey and the Scratch programming language. Other workshops involve making a wearable using the BBC micro:bit that supports the game rock-paper-scissors, adapting content from the make:code site\(^{15}\), and using Scratch to develop an orchestra which the participants can then ‘conduct’ using the computers camera and a ‘baton’ fashioned out of craft materials. All involve the creation of an artefact using both physical and digital materials.

9.4.1 Sample One-off Workshop

Table 9.3 outlines one of the OurKidsCode workshops. This workshop gets the families to create an artefact incorporating music and dance. It uses the Makey Makey (Collective & Shaw, 2012), a tool for constructing physical interfaces, and the Scratch programming language (Resnick et al., 2009). The central activity involves building a series of switches using paper plates and aluminium kitchen foil which connect to the Makey Makey and are used to trigger sound effects from a computer via the Scratch programming language. Families are then invited to prepare a set of instructions (or dance moves) to allow a participant to play a short tune, activating the switches by stepping on them. Families then exchange instructions to experience each other’s creations. The workshop is designed to be completed within the 60-90 minute timeframe identified as DC2 in Table 8.1 Delivery design challenges.

\(^{15}\) https://makecode.microbit.org/projects/rock-paperscissors

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<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Setup</strong></td>
<td>The families settle in, and the facilitator makes sure everyone has refreshments, that the participants’ devices can access the necessary online resources for the workshop and that they have the necessary support materials.</td>
</tr>
<tr>
<td><strong>Introduction</strong></td>
<td>The facilitator briefly introduces the overall workshop model and explains the timeline for the rest of the session.</td>
</tr>
<tr>
<td><strong>Icebreaker</strong></td>
<td>The facilitator introduces the dance mat idea and shares the basic rules of the challenge. The families work on paper to design a set of dance steps and then challenge another family to perform the dance by following instructions. This is intended to reduce inhibitions between families so that they are more likely to share knowledge and support during the following ‘Create’ phase. This phase also introduces the idea of giving instructions to be followed in a specific sequence.</td>
</tr>
<tr>
<td><strong>Create</strong></td>
<td>This is the longest phase of the workshop. The facilitator gives a short introduction to the Makey Makey, explaining the basic idea of closing a circuit. A simple hand-holding activity gives participants a concrete demonstration of how circuits work with the Makey Makey. The families are encouraged to explicitly identify “Maker”, “Coder”, and “Planner” activities and roles, giving them some guidance in structuring the family effort. Family members are encouraged to exchange roles during the activity, so participants do not become stuck in a single role. Families then make a set of paper-plate ‘switches’ and connect them to the Makey Makey. They decorate and personalise the ‘switches’ as they make them. This encourages creativity and play during the workshop, and also provides opportunities for family members of all ages to make enjoyable and meaningful contributions, even in cases where they are not directly interested in coding. A program is built in Scratch which plays selected musical notes on key presses triggered using the Makey Makey. This is generally characterised by exploratory coding and physical activity as families investigate the capabilities and needs of the Makey Makey platform. Simple musical composition and choreography are included in the design of the challenge allowing families to integrate a range of creative interests.</td>
</tr>
<tr>
<td><strong>Share</strong></td>
<td>Families are invited to try each other’s dances, typically with a ‘caller’ from the family who designed the challenge giving instruction to a participant from another family activating the switches, in a mirror of the Icebreaker activity.</td>
</tr>
<tr>
<td><strong>Reflect</strong></td>
<td>Families discuss and share experiences, and the facilitator encourages discussion and planning for future activities. Families are given micro:bits and OurKidsCode Cards with instructions for the Rock/Paper/Scissors activity to complete at home.</td>
</tr>
</tbody>
</table>

*Table 9.3: Sample OurKidsCode one-off workshop*
9.4.2 Support Materials

Design Challenges DC1 and DC4 identified in Section 8.2, identified a need for support materials for the organisation and running of the workshops, as well as for continuing activities outside the workshops. In response to this, materials were developed to support the workshop facilitators and families.

The use of cards to aid design processes is common practice in DBR in order to make knowledge produced by the research as well as other domain knowledge accessible to designers (Deng et al., 2014; Hornecker, 2010). Deng et al. (2014) point to a number of advantages of the card form: the small physical form of cards affords physical manipulation; cards can serve as a physical reference during design discussion, facilitating communication and shared understanding; and they can be used to bookmark discussion ideas. Hornecker (2010) characterises their use in this context as ‘tangible interaction’. Sadka & Zuckerman (2017) used these affordances to design Activity Cards to assist parent-mentors in a home-based co-making activity. These efforts inspired the creation of the “OurKidsCode Cards”, a series of A5 printed activity, support, and technical cards which provide both facilitators and participants with guidance. The cards are designed to give participants clear stepped instructions for activities along with troubleshooting advice. They also give facilitators guidelines for running the workshop and provide the rationale and background information as well as ideas for follow-on activities. The supporting cards are divided into five groups which are coded by both colour and title for ease of identification during the workshop. Each workshop makes use of a specific set of cards which the facilitator organises ahead of the workshop proper. A sample card can be viewed below in Figure 9.3. Further samples and a breakdown of the different types of cards can be found in Appendix E.
Participants and facilitators also have access to a supporting website developed by the researcher (http://ourkidscode.ie\textsuperscript{16}), which contains descriptions of the workshop model, and downloadable copies of the cards and provides support and encouragement for families to undertake follow-on activities. In order to further encourage future activities, the project gave each family a micro:bit to take home with them for future projects\textsuperscript{17}

9.5 Next Steps

This chapter described the development of an initial design for interventions to support PI in CS Education using the draft Design Principles as a foundation. The next step was to implement and evaluate this design in order to explore both the efficacy of the Design Principles and the sample workshops based on those principles. The following chapter outlines this implementation and evaluation and describes the consequential adjustments and evolution of the design of the interventions. The impact of this process on the draft Design Principles and how it addresses the research questions is discussed in Chapter 11.

\textsuperscript{16} The currently available website was updated by the programme manager in late 2021.

\textsuperscript{17} Micro:bits were provided by Microsoft Ireland.
10. Design Experiments: Implementation and Evaluation

10.1 Introduction
This chapter begins with an outline of the common evaluation design used for all of the experiments. As this was an iterative process with the evaluation findings of each experiment leading to refinements in the design, it continues by describing the implementation and evaluation findings of the one-off workshops and their implication for the design, before moving on to discuss the evaluation of the four-part programme. Following from this, a complementary experiment, consisting of CPD workshops to train facilitators, is described. A full discussion of the implications of the findings of all of the experiments for both RQ1 and RQ2 along with any limitations is deferred to the following chapter, 11. Design Experiments: Discussion.

The evaluation of the one-off workshop has been discussed in previous collaborative papers (Bresnihan et al., 2019a, 2019b). The evaluation was designed by the researcher, but she was assisted in the data collection by other members of the team as described in Section 10.2. Data analysis was conducted by the researcher unless specifically stated otherwise. The design of the four-part programme described in Section 10.4.1 was a collaborative process.

10.2 Evaluation Design
DBR frames its research approach as “an iterative endeavour of progressive refinement” (E. E. Scott et al., 2020). In direct contrast to an experimental approach which is concerned with the control of variables, DBR foregrounds the importance of context, and its (often unanticipated) effects on the effectiveness of an intervention and believes that it should be included in the research analysis (Barab & Squire, 2004; Maxwell, 2004a). Consequently, DBR is less concerned with controlling the research conditions - as in an experimental approach - and instead focuses on characterising the learning environment (Barab & Squire, 2004). The intention being that these characterisations provide important insights into what specific features of the instructional tools, or the learning environment, were most impactful to learning (Design-Based Research Collective, 2003).
Barab’s (2014, pp. 165–66) nine-step framework for conducting DBR (Table 10.1) was used as a guiding framework, with the interventions being evaluated using an iterative approach. Each cycle led to refinements in the implementation process and improvements in the design.

<table>
<thead>
<tr>
<th></th>
<th>Make explicit the assumptions and theoretical bases that underlie the work.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Collect multiple types of theoretically relevant data.</td>
</tr>
<tr>
<td></td>
<td>Conduct ongoing data analyses in relation to theory.</td>
</tr>
<tr>
<td></td>
<td>Acknowledge the inseparability of the design and implementation.</td>
</tr>
<tr>
<td></td>
<td>Distinguish between outcomes and outputs.</td>
</tr>
<tr>
<td></td>
<td>Illuminate the hidden curriculum and accompanying agendas.</td>
</tr>
<tr>
<td></td>
<td>Invite multiple voices to critique theory and design.</td>
</tr>
<tr>
<td></td>
<td>Have multiple accountability structures.</td>
</tr>
<tr>
<td></td>
<td>Engage in dialectic among theory, design, and extant literature.</td>
</tr>
</tbody>
</table>

Table 10.1 Barab’s nine-step framework (2014, pp. 165–166)

Following Barab’s framework, the underlying theoretical assumptions underpinning this research were established in Chapters 6 and 7 (Step 1), the researcher then engaged in collecting questionnaires, focus group, image, sound and artefact evidence from each workshop as outlined in Section 10.2.1 below (Step 2). The research questions were reviewed during team meetings after each workshop intervention (Step 3) and documented in meeting notes along with workshop design enhancements (Step 4), with longer term outcomes re-evaluated in accordance with the analysis and reporting of new data (Step 5). Assumptions and influences acknowledged during the workshops, as well as researcher bias, were explored and captured in team meeting updates and fieldnotes and subject to ongoing reflexivity through the keeping of a research diary (Step 6). Multiple voices were invited to critique theory and design - the researcher was present in each implementation, thus on hand to solicit feedback and answer questions from participants and facilitators. In addition, expert focus groups, regular steering committee meetings and team meetings were used as opportunities to elicit different perspectives (Step 7). Finally, (Step 8), research findings were communicated through reporting to funders, and further reviewed through academic presentation and publication (Step 9). This DBR framework thereby provided a flexible structure that could be adapted to capture change over time with the capacity to manage the complexity of conducting social research. The methods are described in more detail in the following sections along with the findings and their implications for the Design Principles.
10.2.1 Research Questions & Data Collection

The evaluation primarily looked to further explore **RQ2**: What principles should inform the design of interventions to support PI in CS Education? The investigation of **RQ1** undertaken in Chapters 4, 5, & 6 of this dissertation concluded that if parents’ own computing confidence can be increased, this may have a positive impact on parental attitudes towards, and motivation for, involvement with their children’s CS development. Other factors that were found to be predictors are parents’ programming experience, computing availability, as well as usage of technology for creative purposes. Therefore, the following questions needed to be explored:

- a) Did the interventions effectively implement the identified draft Design Principles?
- b) Did this have an impact on these predictor factors?
- c) Did this in turn have any impact on PI attitudes and/or PI behaviour?

This effort involved collecting data from multiple sources as the research progressed. In line with this, multiple mixed methods were used in the evaluation of the experiments. As the research was exploring psychological constructs (primarily parents’ attitudes and intentions), the study focused on parents’ perceptions rather than objective skill measures. E.g. data collection instruments were designed to investigate changes in participants’ confidence by recording self-reported confidence pre- and post- workshop. The post-questionnaires also captured their perception of the workshop/s and any impact on PI attitudes by capturing changes to their future intentions. Follow-up questionnaires explored changes to PI behaviour. All these were supplemented by the collection of qualitative data in the form of observations, fieldnotes, photos and a post-workshop focus group. The data-collection timeline is summarised below in Figure 10.1.

![Figure 10.1 Data-collection timeline](image-url)
The data collection instruments administered are outlined below in Table 10.2 and more details about the questionnaires are given below. Copies of all the instruments are included in Appendix F.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Sample</th>
<th>Context</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-questionnaire (Quantitative)</td>
<td>Parents</td>
<td>Pre-Workshop</td>
<td>Questions and scales adapted from validated instruments (Papastergiou, 2008) to capture confidence and previous experience.</td>
</tr>
<tr>
<td>Observation (Qualitative)</td>
<td>Parents, Children</td>
<td>Throughout workshop</td>
<td>Template to capture observations of parent and child behaviours (Spradley, 2016).</td>
</tr>
<tr>
<td>Fieldnotes (Qualitative)</td>
<td>Parents, Children</td>
<td>Throughout workshop, Post-workshop</td>
<td>Template to capture planning, administration, design, logistics and theoretical issues as well as practical influences which impact workshop delivery written prior to and after workshops (R. M. Emerson et al., 2011).</td>
</tr>
<tr>
<td>Artefacts (Products of the Workshop) (Qualitative)</td>
<td>Parents, Children</td>
<td>End of workshop</td>
<td>Photographs of artefacts produced (Hammersley &amp; Atkinson, 2007).</td>
</tr>
<tr>
<td>Focus Group (Qualitative)</td>
<td>Parents</td>
<td>End of workshop</td>
<td>Semi structured conversation (Spradley, 2016) exploring learning outcomes. Audio recorded.</td>
</tr>
<tr>
<td>Post-questionnaire (QUANT + qual)</td>
<td>Parents</td>
<td>Immediately post-workshop</td>
<td>Questions and scales adapted from validated instruments (Papastergiou, 2008; Vekiri, 2010) to capture confidence, reactions, learning and future intentions.</td>
</tr>
<tr>
<td>Follow-up Questionnaire (QUANT + qual)</td>
<td>Parents</td>
<td>&gt;2 months post workshop</td>
<td>Sent &gt;2 months post-workshop to evaluate the extent of any follow on activity (Kirkpatrick, 2007).</td>
</tr>
</tbody>
</table>

Table 10.2: Data collection instruments

10.2.1.1 Pre- and Post-Questionnaires
The pre- and post-questionnaire instruments contain ten Likert-type items to assess changes in confidence, each with five responses (“strongly disagree” to “strongly agree”). It was adapted from a set designed to investigate teachers’ attitudes to programming before and after engaging in a creative computing (Oldham et al., 2018) which had been previously adapted from one designed to measure Greek high school students’ computing self-efficacy (Papastergiou, 2008). The original set formed a scale with the value of Cronbach’s alpha being .89. Cronbach’s alpha measures the internal consistency of a set of items, assigning a value between 0 and 1; higher values indicate greater consistency and hence are deemed to
reflect greater reliability for the resulting scale, with the value of .89 typically regarded as “good” verging on “excellent” (Gliem & Gliem, 2003).

As well as the confidence scale, the post-questionnaire also contains eight items designed to measure the effectiveness of the implementation of the workshop Design Principles. These were adapted for this purpose from a scale developed to measure perception of Information Systems’ Instruction in Greek middle schools. The complete scale had an ‘acceptable’ Cronbach’s alpha of .71 (Vekiri, 2010). As this study adapts the scales to a different context further validation was undertaken as part of the data analysis (Sections 10.3.2 and 10.4.3).

Two new items were included in the pre- and post- questionnaires to assess the impact of the workshop on future intentions with regard to PI:

- I would like to take part in computing activities with my family in the future.
- I feel able to organise computing activities with my family at home.

10.2.1.2 Follow-up Questionnaire

The follow-up questionnaire was designed to explore whether the intervention led to any change in behaviour among the participants (this aligns with level 3 in terms of the highly influential Kirkpatrick evaluation model (Kirkpatrick, 2007)). It contains 13 items including five quantitative items related to future intentions and follow-on behaviours. For example:

- Item 6: When you left the workshop, how eager were you to engage in further computing activities with your family?
- Item 7: How well prepared were you to do any further computing activities?
- Item 8. Did you go on to do further computing activities with your family or with other families?

A further four items were qualitative and explored the nature of any future activity. The remainder were designed to collect demographic data.

10.2.2 Data Analysis

10.2.2.1 Quantitative Data Analysis

Data from pre- and post- questionnaires were entered into SPSS. The responses to items 1-10, dealing with self-reported confidence levels pre- and post-workshop were then scored from 1 to 5, or from 5 to 1, so that in each case the higher number reflected greater reported “confidence”. Frequency distributions and descriptive statistics were calculated.
With a view to measuring the change in reported confidence, Cronbach’s alpha was computed in order to discover if the items, or a subset of them, could form a scale. If so, the item scores were added and the totals divided by ten, to give a value in the range 1 to 5. This was done for both the pre- and the post-questionnaire.

When it came to comparing the pre-workshop and post-workshop scores, the Shapiro-Wilk test was used as the samples were small. Once this indicated that the distributions could be treated as normal, paired t-tests were carried out to see if there was a significant difference in the means before and after the workshop. For the final two items exploring change in future intentions, a similar process was followed.

With regard to the eight items exploring the perceptions of the workshop, the responses to these questions were scored from 1 to 5, or from 5 to 1, so that in each case the higher number reflected greater reported more positive perceptions. As the sample was small and the questions diverse, the mean response for each question was calculated and is displayed (Figure 10.3 and Figure 10.17).

Sample sizes for the experiments were small and self-selecting in nature, the quantitative findings are therefore limited in their validity and reliability. However, their replicability across the different experiments was notable and they are presented here to provide important triangulation for the rich qualitative data collected. A more detailed discussion of these limitations is provided in Section 11.4.

10.2.2.2 Qualitative Data Analysis

Preparation for the qualitative data analysis began by gathering and organising the data as outlined below in Table 10.3.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Initial Format</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>Template plus handwritten notes.</td>
<td>Collated and entered into a single text document</td>
</tr>
<tr>
<td>Fieldnotes</td>
<td>Handwritten notes, meeting minutes, planning documents</td>
<td>Collated and entered into a single text document</td>
</tr>
<tr>
<td>Artefacts</td>
<td>Photographs of artefacts produced</td>
<td>Organised by workshop date</td>
</tr>
<tr>
<td>Focus Group</td>
<td>Audio recording</td>
<td>Each recording transcribed into a text document</td>
</tr>
<tr>
<td>Post-questionnaire</td>
<td>Handwritten surveys</td>
<td>Qualitative data identified and entered into a spreadsheet</td>
</tr>
<tr>
<td>Follow-on questionnaire</td>
<td>Online survey</td>
<td>Data downloaded as spreadsheet.</td>
</tr>
</tbody>
</table>

Table 10.3 Preparation of qualitative data for content analysis
The written material was then read through several times in order to become immersed in the data and get a “sense of the whole” (Elo & Kyngäs, 2008, p. 109). Following this, the analytical process outlined by Campbell et al. (2013) and described earlier in Section 3.5.2, was again deployed. This used three stages and two researchers to code and theme the data. The first step identified key concepts or variables using the existing research in order to develop a coding scheme. These pre-determined codes related to the key concepts under investigation and therefore included the factors identified by the survey and the draft Design Principles. The analysis was also left open to the inductive identification of new categories for relevant findings that do not fit into these pre-determined codes (Hsieh & Shannon, 2005). Consequently, this set was further extended and modified through this initial reading and rereading of the data.

In order to support the coding process and ensure consistency, step two involved establishing intercoder agreement of the coding scheme. This involved the two coders (the researcher and a Research Assistant with experience in ethnography and qualitative analysis) operating separately on a sample of the data to see if the same codes were chosen for the same units of text (intercoder reliability) (Krippendorff, 2018), followed by discussion and resolution of any discrepancies (Campbell et al., 2013). A related set of key words that would indicate the articulation of these concepts was also developed. Table 10.4 presents this initial set of codes, definitions, and keywords used for the analysis.

<table>
<thead>
<tr>
<th>Concept/Category</th>
<th>Sub-category</th>
<th>Description</th>
<th>Example Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors that have an impact on PI in CS Education (RQ1)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>Confidence (positive)</td>
<td>Positive indications of one’s confidence in CS</td>
<td>Confident, no fear</td>
</tr>
<tr>
<td></td>
<td>Confidence (negative)</td>
<td>Negative indications of one’s confidence in CS</td>
<td>Setbacks, apprehensive</td>
</tr>
<tr>
<td>Usage</td>
<td>Creation</td>
<td>use of technology to ‘create’ something</td>
<td>Programming, Scratch, Robotics, websites</td>
</tr>
<tr>
<td></td>
<td>Consumption</td>
<td>Passive use of technology</td>
<td>Screentime, social media, games</td>
</tr>
<tr>
<td>CS Experience</td>
<td>Experience (positive)</td>
<td>Previous experience of CS</td>
<td>Technical, experience, coding, job</td>
</tr>
<tr>
<td></td>
<td>Experience (negative)</td>
<td>Lack of CS Experience</td>
<td>Challenging, new to technology, no experience, lost</td>
</tr>
<tr>
<td>Availability</td>
<td>Devices &amp; Internet</td>
<td>Access to hardware good quality internet</td>
<td>Laptop, iPad, micro:bit, Makey Makey. Getting online, download</td>
</tr>
<tr>
<td>Learning environment</td>
<td>Access to a suitable venue</td>
<td>Location, space, desks</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>PI Attitude</td>
<td>Willingness to be involved in child’s CS Education. Indications of interest in further activities.</td>
<td>Doing more, project ideas, more involved,</td>
<td></td>
</tr>
<tr>
<td>Attitude</td>
<td>No willingness to be involved in child’s CS Education.</td>
<td>No interest, not able, no time</td>
<td></td>
</tr>
<tr>
<td>Attitude (positive)</td>
<td>Has been involved in child’s CS Education</td>
<td>Coding together, more activities,</td>
<td></td>
</tr>
<tr>
<td>Attitude (negative)</td>
<td>Has not been involved in child’s CS Education</td>
<td>Done nothing, not organised, no time</td>
<td></td>
</tr>
</tbody>
</table>

**Additional concepts related to the Design Principles (RQ2)**

<table>
<thead>
<tr>
<th>Intra family Collaboration</th>
<th>Positive feelings about intra-family collaboration / evidence of collaboration</th>
<th>Collaboration, working together, family, together, teamwork, Sitting back, over-stretched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intra family Collaboration (positive)</td>
<td>Negative feelings about intra-family collaboration / failure to collaborate</td>
<td></td>
</tr>
<tr>
<td>Intra family Collaboration (negative)</td>
<td>Positive feelings about inter-family collaboration / evidence of collaboration</td>
<td>Collaboration, interaction, others to ask, helping others</td>
</tr>
<tr>
<td>Inter-family Collaboration (positive)</td>
<td>Negative feelings about inter-family collaboration / failure to collaborate</td>
<td>lack of collaboration, no interaction</td>
</tr>
<tr>
<td>Activity model (positive)</td>
<td>Positive feelings about the workshop activities</td>
<td>Timing fine, structure, instructions</td>
</tr>
<tr>
<td>Activity model (negative)</td>
<td>Negative feelings about the workshop activities</td>
<td>Too long, break, rushed</td>
</tr>
<tr>
<td>Activity model</td>
<td>Involvement in designing and shaping the workshop</td>
<td>Doing our own thing, independence, decision-making.</td>
</tr>
<tr>
<td>Co-creation</td>
<td>Considerations of the ‘making’ element</td>
<td>Concrete, craft, making, connecting, result</td>
</tr>
<tr>
<td>Creativity</td>
<td>Examples of or references to creativity</td>
<td>Experimenting, possibilities, music, colour, creativity</td>
</tr>
<tr>
<td>Creativity</td>
<td>Positive feelings about the sharing of outcomes</td>
<td>Dancing, Playing Rock Paper Scissors, sharing</td>
</tr>
<tr>
<td>Creativity</td>
<td>Negative Feelings about the sharing of outcomes</td>
<td>Shy, silly, embarrassed, self-conscious</td>
</tr>
<tr>
<td>Reflection</td>
<td>Evidence of reflective behaviour</td>
<td>Explaining, understanding, talking through</td>
</tr>
</tbody>
</table>

Table 10.4 Directed content analysis initial codes
The third step involved the coders deploying the coding scheme on the data using the qualitative analysis software NVivo 12 Plus. Even at this stage, data that could not be coded was identified and analysed to determine if they represented a new category or a subcategory of an existing code. These emergent codes, definitions, and keywords are displayed below in Table 10.5.

<table>
<thead>
<tr>
<th>Concept/Category</th>
<th>Sub-category</th>
<th>Description</th>
<th>Example Keywords</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emergent Concepts (finalised and agreed following intercoder agreement)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constructivism</td>
<td>Self-directed learning</td>
<td>References to learner-directed nature of interventions</td>
<td>Self-directed, spoonfed, try again, problem solving</td>
</tr>
<tr>
<td>Facilitation</td>
<td></td>
<td>Considerations of the role of the facilitator</td>
<td>Facilitator, teacher, help</td>
</tr>
<tr>
<td>Roles</td>
<td></td>
<td>Nature of the groupwork</td>
<td>Roles, delegation, tasks</td>
</tr>
<tr>
<td>Engagement</td>
<td>Positive</td>
<td>Evidence of enjoyment and engagement</td>
<td>Engaged, enjoyed, flies along, interesting, fun.</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Evidence of boredom or frustration</td>
<td>Less engaged, homework,</td>
</tr>
<tr>
<td>Materials</td>
<td>Positive</td>
<td>Benefits of the materials</td>
<td>Clear, instructions, cards, guides</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>Includes suggestions for improvement</td>
<td>Improvement, cards, instructions, step-by-step</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td>Self-reported instances of CS learning.</td>
<td>Learning, picked up, figuring out</td>
</tr>
</tbody>
</table>

Table 10.5 Emergent codes

Appendix G provides an example from NVivo of the qualitative data and the codes that were ascribed to the text.

The data was then examined in relation to the evaluation research questions, with the aim of exploring how the data collected validated or invalidated the draft Design Principles (RQ2), and whether it served to further build upon or elaborate those principles. In addition, consideration was also given as to whether the findings served to provide any further insight into the factors that were identified as having an impact on parental attitudes towards PI in CS Education (RQ1).
10.3 Design Experiment 1: One-off Workshops

The exploratory Design Experiments began by implementing and evaluating the one-off workshops described in the previous chapter. Three of these workshops took place between September and December 2018. Their implementation, evaluation and findings are described below.

10.3.1 Recruitment & Implementation

Purposive maximum-variation sampling was used to recruit three primary schools. This provided a diverse range of relevant cases (one urban, two rural). Convenience sampling was then used to recruit the participant families which took place through the school principals and Parent Associations of the selected schools.

In total 53 participants across 18 families (18 parents and 36 children aged 5-13) took part across the three workshops (Table 10.6).

<table>
<thead>
<tr>
<th>Workshop</th>
<th>Location</th>
<th>Families</th>
<th>Parents</th>
<th>Children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop 1</td>
<td>Large urban school</td>
<td>6</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>Workshop 2</td>
<td>2 small rural schools combined</td>
<td>5</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>Workshop 3</td>
<td>Large urban school</td>
<td>7</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>18</td>
<td>18</td>
<td>36</td>
</tr>
</tbody>
</table>

Table 10.6: One-off workshop participants

Of the 18 parent participants four were male and 14 female. They ranged in age from 37 to 63 with 14 out of the 18 aged 43-53. The children ranged in age from 5 to 13 but fell predominantly between 7 and 11 (Figure 10.2).

![Figure 10.2 Child participants' age](image-url)
10.3.2 One-off Workshop Findings

The data analysis looked to establish if the workshops effectively operationalised the draft Design Principles. It also explored whether this had an impact on parents computing attitudes and any subsequent impact on PI attitudes and/or PI behaviours. The data were also examined for further insights into RQ1 in order to provide triangulation and complementarity to the survey analysis outlined in Chapter 6. Qualitative results from the observations, fieldnotes, focus groups and open questions in the follow-up questionnaire were supplemented by the quantitative findings of the surveys.

10.3.2.1 Did the interventions Effectively Implement the Draft Design Principles?

The results of the eight items exploring the participants' perception of the workshop in the post-questionnaire were first examined to explore whether the workshop design successfully implemented the draft Design Principles. As outlined in Section 10.2.2.1, the 16 responses to these questions were scored from 1 to 5, or from 5 to 1, so that in each case the higher number reflected greater reported more positive perceptions. The mean response for each question was then calculated and is displayed below in Figure 10.3.

As can be seen, the mean responses to all but one of the items scored between 4 ('agree') and 5 ('strongly agree'). This indicates the successful implementation of some of the draft Design Principles identified in Section 7.3, particularly DP5, with its emphasis on creativity and the making of a meaningful artefact, and DP1’s consideration of the importance of intra-family collaboration. Slightly lower scores, although still largely positive, were recorded for the activities relating to the families’ interests and for learning about computing which indicated that more attention to DP4 (eliciting the families’ input) was needed.
The observations were particularly useful for evaluating the implementation of the Design Principles. An important finding here was the importance of the ‘craft’ or ‘making’ element involved in the implementation of DP5, the making of a meaningful artefact. Examples of this can be seen in Figure 10.4 below and include the construction and decoration of a wristband to turn a micro:bit into a wearable and the making of a physical dance mat from paper plates wired up to a Makey Makey. Indeed, some participants were observed to be more engaged by ‘making’ than computing, and providing it helped to maintain connection with the task. This resulted in enhanced collaboration and dialogue within the families (DP1, DP7).

![Figure 10.4: ‘Making’ elements](image)

A surprising degree of creative exploration was observed by families as the workshops progressed (DP4, DP5) indicating growing confidence and a willingness to risk unknown outcomes. For example, in the Dance Mat workshop described in Section 9.4.1, the OurKidsCode Card guides families towards five note songs, matching the most easily used inputs of the Makey Makey. Despite this, a number of families explored some of its more advanced features. These included using additional inputs offered by the Makey Makey that extend the musical range of their compositions, and coding activities that improve the user experience (such as adding animations or limiting the tendency of a simple program to ‘repeat’ a note after a time). In addition, the Workshop Card advises family members to remove their shoes before standing on the switches (a shoe will often act as an insulator keeping the switch from making a connection), but some families instead opted to create accessories to be worn over their shoes, making use of conductive materials provided as part of the ‘making’ supplies in the workshop (see Figure 10.5 below for a typical example).
Similar creativity was shown when designing the ‘dance’ activities, and some families chose to involve an entire family in the dance with a family member assigned to each switch (all members holding hands to create a circuit), making the activity more of a collaboratively played musical instrument than a dance challenge (Figure 10.6). The observations also recorded considerable excitement and laughter culminating during the ‘Share’ phase where participants had a chance to show off their creations, reinforcing the hypothesis about its importance in the implementation of DP6 (giving participants a sense of celebration) and DP2 (encouraging inter-family support and communication).

Fieldnotes for the most part consisted of practical and logistical issues and suggestions for improvements (see Figure 10.7). These had an iterative impact on the design of the workshop and the materials.
A lot of these involved the OurKidsCode Cards which were observed to be of great support to the participants and encouraged them to be more self-sufficient. They were therefore revised and refined after each session. For example, in the first workshop it was noted that family members were uncertain about what roles they should play so it was decided that a card be developed to clarify this (see Appendix E). This was implemented in the second workshop and observed to work well with families working together to complete the activities. However, there was not a great deal of inter-family collaboration (DP2) during the ‘Create’ phase and the families tended to go straight to the facilitator with questions rather than looking to other families.

10.3.2.2 Did this have an Impact on the Predictor Factors?
Confidence, availability, experience and the creative usage of computers had previously been identified as predictor factors for positive attitude towards and motivation for PI in CS Education. The pre- and post- questionnaires were analysed with a view to measuring the change in self-reported confidence, Cronbach’s alpha was computed in order to discover if the responses dealing with self-reported confidence levels, or a subset of them, could form a scale. For all ten items, the value was .945, which is deemed “excellent”. The item scores were added and the totals divided by ten, to give a value in the range 1 to 5. This was done for both the pre- and the post- questionnaire.

When it came to comparing the pre-workshop and post-workshop scores, the analysis was restricted to two sets of thirteen scores as only thirteen of the eighteen parent participants fully completed the set of ten items. The Shapiro-Wilk test was used as the samples were
small. It indicated that the distributions could be treated as normal; and so, paired t-tests were carried out to see if there was a significant difference in the means before and after the workshop.

The two sets of self-reported confidence scores are presented graphically in Figure 10.8, with each line representing a parent participant. It can be seen that the confidence levels were already high pre-workshop, with only three participants returning a score below the midpoint of the scale (this is almost certainly the result of the self-selecting nature of the sample). Two participants actually returned slightly lower scores at the end than at the beginning of the cycle. However, of the other eleven, one stayed the same and ten returned increased scores. Overall, the mean score rose from 3.44 to 3.74, and the difference is statistically significant at the .05 level (t = 2.835, df = 12, p = .015). However, the small sample size means that we need to be wary of interpreting this as reflecting a real effect (Leppink et al., 2016).

![Figure 10.8 Change in confidence levels](image)

The transcripts of the focus groups were analysed as described in Section 10.2.2.2 and provided a particularly rich source of data with regard to the predictor factors. While availability did not emerge as a theme (all participants brought their own devices to the workshops suggesting availability was a non-issue for them), experience, usage, and confidence did, and the discussion provided a deeper understanding of these factors.
Lack of confidence emerged strongly as an inhibitor of PI: “I didn’t have any idea of what internet technologies are, a little bit more understanding of their role. . . . I was new to technology.” However, many remarks were made about increased confidence as a result of the activity, supporting the findings from the questionnaires that overall confidence increased. This was reflected in comments such as “if it doesn’t work the first time, you just go back, and try it again” and “we figured it out, yeah it was like, you still have to follow your own method,” as well as “it was a good case of you weren’t going to be unable to do something. It wasn’t totally spoon-fed to you either, you know what I mean?”. These comments also supported the idea that self-directed nature of the learning led to this increased confidence.

There was evidence during the focus group that the creative usage of computing during the workshops was something that was important for the families. When asked what they enjoyed, creating and sharing the artefacts were mentioned repeatedly by both children and adults. One parent remarked that “it’s really good to have something concrete at the end, you start, and you work through the tasks, you know, I can see it.” Again, this also indicated the importance of DP3 and DP5.

With regard to experience, the focus group revealed it to be a more complex factor. While those without experience reported a lack of confidence, one parent who worked in technology revealed that they had a tendency to take over. The structure of the workshop mitigated against this by providing the families with guidance for the roles they could play, and they commented that they enjoyed the experience of observing their children coding: “they really loved coding on their own while I was being there . . . really listening.” Another experienced parent could visualise the potential of learning coding at home together: “computers and coding is my area so it’s great that kids can code, and I can see how families fit around a table and program,” but had previously felt somewhat disconnected from getting involved: “so, you know coding in our house, probably not something I can feel necessarily involved in, on a day to day basis, but having a more positive approach to, see the value it can bring to your life”.

10.3.2.3 Did this in turn have any Impact on PI Attitudes and/or PI Behaviour?

There was some evidence from the focus group that the intra-family collaborative and creative usage of computing during the workshops had changed attitudes to PI. One parent realised that this was an option that could be practiced at home with family members: “I think we learnt that um, that everyone could work on different things, and be independent
in teams, and that we can, do things together, em, I think in our house, we will think about how it will work, using different gadgets, and bits, and yeah, it’s some, it’s another way to bring us together.” Participants also reported that they were more likely to engage in similar activities at home: “I would like to get them more involved, you know? I’d like to push it a bit more I think” indicating a more positive attitude to PI.

In the post-questionnaire 14 participants responded to the two items measuring the future intentions of the workshop. A similar analysis process to the confidence items was followed and results are displayed and discussed below.

Unsurprisingly, as the participants were self-selecting, nine already strongly agreed pre-workshop that they would like they would like to take part in computing activities with their families in the future. Hence, any rise was not statistically significant. However, as can be seen from Figure 10.9, post-workshop the number strongly agreeing had increased to 12. Of the others, one had increased from ‘neither agree nor disagree’ to ‘agree’ and only one had dropped from ‘agree’ to ‘neither agree nor disagree’.

When asked post-workshop whether they felt able to organise CS activities with their families 10 out of the 14 respondents reported feeling more able than pre-workshop with four remaining the same (Figure 10.10). Here the mean rose from 2.86 to 3.93, a significant rise at the 0.5 level.
The response rate to the follow-up questionnaire was lower. However, while limited by the small sample size (n=9), the responses did serve to further support the pre- and post-questionnaire findings. All nine of the respondents reported feeling either “very” eager (n=4) or “quite” eager (n=5) to engage in further computing activities with their families when they had left the workshops. In addition, four participants felt “very” prepared and five “quite” prepared to do further computing activities (Figure 10.11). It should be noted however that their eagerness to engage further only correlated to their preparedness in five of these cases.

Five respondents did go on to do further computing activities with their family or other families (Figure 10.12). However, again there was little to no correlation between those who did so and those who reported being “very” eager and “very” prepared.
Finally, all five families who reported that they had completed further computing activities plan more in the future (Figure 10.13).

When asked an open question in the follow-up questionnaire about what they recalled learning in the workshop, four of the respondents just outlined the activity itself. The others, however, were more reflective, with one commenting “That my child has no fear when it comes to technology and dives straight in, I am much more apprehensive but would like to know more”. Another spoke of the importance of “creative teamwork and the delegation of tasks”. The survey also asked the five respondents who had gone on to engage in further activity what they had done and what further activities they planned. While the activities varied, they all mentioned using Scratch as a tool (Table 10.7).
Table 10.7 Further activities

<table>
<thead>
<tr>
<th>Respondent</th>
<th>Activity Completed</th>
<th>Activity Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>We set time aside to code every week. We usually set ourselves a task or download Scratch worksheets.</td>
<td>It won’t be a family activity as such, but kids have plans to enter Coolest Projects18 2019.</td>
</tr>
<tr>
<td>R2</td>
<td>We made a Scratch game together, him leading me and explaining how to build the program script</td>
<td>To build some more games with Scratch, possibly introducing some live action or movie making with a pro4 camera</td>
</tr>
<tr>
<td>R4</td>
<td>Did more activities with micro:bit.</td>
<td>Entering National Scratch competition and Coolest Projects</td>
</tr>
<tr>
<td>R8</td>
<td>Bought equipment to make our own game</td>
<td>Our daughter was really inspired by Scratch, and I am very hands-on with creative projects so we would love to do more of the same kind of activity... . My husband and daughter plan to look at Python together.</td>
</tr>
<tr>
<td>R9</td>
<td>A little Scratch programming but we have not yet tackled the project we brought home to do - due to lack of coordination skills!</td>
<td>We want to do the project we brought home from the session.</td>
</tr>
</tbody>
</table>

The reason that all four respondents who did not engage in any further family activity gave was lack of time, with one respondent expanding “My daughter was very encouraged to try Scratch at home and she has done that but we haven’t done anything together. We have the gift that was handed out at the end of the session, but we haven’t had a chance to set it up yet!”.

10.3.3 Conclusions and Implications for Design Principles

During the focus group, feedback on the workshop as a whole was overwhelmingly positive: “A great idea - I feel very disconnected from my kids’ computer use”, “Thoroughly enjoyed it, time flew. We have already decided to make our own Scratch game together at midterm.” Parents commented about the positive use of computing, comparing it favourably to their usual interactions giving examples of disagreements about screen time and worrying about online usage.

The generally positive findings indicate that the workshop design effectively implemented most of the identified Design Principles. **DPS5**: The interventions should use computers as creative tools and lead to the making of a meaningful artefact was particularly well-received by the families and, along with the ‘Share’ phase (DP6), was key to the enjoyment of the

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18 [https://coolestprojects.org/](https://coolestprojects.org/).
design workshops. The families also clearly indicated their appreciation of collaborating with each other (DP1) and the implementation of DP3. The interventions should consist of structured activities appeared to give the families a sense of control and the feeling that the activity was actually something that they could work through together.

On the other hand, it appeared that more work was needed to implement DP4: Input should be invited, and their existing knowledge and expertise recognised. They should be given the opportunity to become more active in planning and structuring the activities as the intervention progresses. As evidenced by the lower score for the statement about the activities being related to their interests and the lack of qualitative data in the co-creation category. In addition, there was almost no mention of working alongside other families (DP2) in the data.

There was evidence that taking part in the workshop achieved its aim of strengthening the participants confidence and an increased readiness to partake in family computing activities (PI Attitudes) and we know from the post-questionnaire that at least five of the participating families went on to do so (PI Behaviour). This evidence is presented while accepting that there are limitations to the research, particularly the small sample size and its self-selecting nature (the effects of these are more fully discussed in Section 11.4). However, overall the findings provided a positive indication that the Design Principles identified could be successfully used as a basis for interventions aimed at improving attitudes towards PI in CS Education. Subsequent experiments sought to build on this by offering increased opportunities to boost parental competence and self-reliance (DP4) and encourage the establishment of a community of practice (DP2) thereby encouraging the idea of pursuing further activity, as a family unit or along with other families (DP8). This effort took the form of a four-part programme and its design, implementation and evaluation are described in the following section.

10.4 Design Experiment 2: Four-Part Programme
As a stand-alone activity, the one-off workshop was primarily designed to test the Design Principles. The findings indicate that it also succeeded in initiating engagement and building confidence. However, the ultimate aim of increasing PI in CS Education means that there is a need to foster self-reliance and to build a community of learning to support deeper ongoing self-directed activity. With reference to the Design Principles, the evaluation of the workshop concluded that this meant that more attention was needed to implement DP2
(inter-family support), DP4 (families’ input into the design) and DP8 (encouraging further activity). This suggested the need for more sustained engagement. A subsequent Design Experiment, consisting of four-part programme was designed to explore how this best be done and what impact this might have.

10.4.1 Programme Design
The four-part programme continued the emphasis on collaborative family learning and consisted of four 1.5-hour sessions delivered to a group of families weekly over four weeks. In order to build further confidence and self-reliance, it encouraged the families to work on projects at home between sessions and sought to foster a supportive community of learning among participating families. The four workshops continued to use the existing activity model, while scaffolding was employed to gradually increase the responsibilities of the participating families, and decrease those of the facilitator, with the aim of enabling them to become independent of the facilitator by the end of the programme.

The decision to run the programme over four weeks was a pragmatic one. It allows for taking the activity model, outlined in Section 9.3, and delivering it through three iterations over the four sessions (Figure 10.14). In order to facilitate the transition between each iteration there is an addition of a ‘Plan’ phase. The intention is that by working through three different activities in a structured fashion the families can gain both greater familiarity with CS tools and techniques and greater organisational knowledge for further family CS activities.

![Figure 10.14 Use of the Activity Model over the course of the four-part programme](image)
Participants are supported in their acquisition of a solid foundation while their increasing independence is encouraged as their understanding becomes more secure. This element of the programme design, firmly based on social constructivism’s concept of ‘scaffolding’ (discussed in Section 7.2.3), is outlined in the following section.

10.4.1.1 Scaffolding and Supports

As previously discussed in Section 7.2.2, social constructivism posits that learners’ construct knowledge through social interaction, interpretation and understanding (Vygotsky, 1980). Learning is therefore viewed as a process of active knowledge construction within and from social processes. However, social constructivism does not remove the need for the teacher; rather it redirects teacher activity towards the facilitation of a safe environment in which student knowledge construction and social mediation can take place. In practice, this requires facilitators to understand the requirements and stages through which participants travel on their journey towards understanding, which in turn might successfully be mediated in the socio-cultural space (Wood et al., 1976). As they work through these stages, the participants begin by needing the active support of the facilitator but, as they become more confident in their thinking and acquire new skills and knowledge, that support is gradually faded. In social constructivist terms, this carefully structured support of the learning journey is known as ‘scaffolding’ and is the key requisite of facilitation (Vygotsky, 1978).

Accordingly, the facilitation of the workshops over the course of the programme is transferred gradually from the facilitator to participants as outlined in Table 10.8. Throughout, the facilitator continues to guide the participants’ emerging understanding, providing assistance as needed.

<table>
<thead>
<tr>
<th>Week</th>
<th>What happens in the workshop</th>
<th>Facilitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Catalyst activity, share outcomes.</td>
<td>Facilitator controls and guides the learners’ activities.</td>
</tr>
<tr>
<td></td>
<td><strong>Homework:</strong> to choose next activity out of three provided choices.</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Discuss activity two selection and start activity two.</td>
<td>Facilitator and participants share responsibilities.</td>
</tr>
<tr>
<td></td>
<td><strong>Homework:</strong> to choose next activity from seven provided websites.</td>
<td></td>
</tr>
</tbody>
</table>
| 3    | Finish activity two and share outcomes  
Discuss activity three selection. | Facilitator and participants share responsibilities with the participants taking the lead. |
Homework: to familiarise themselves with Activity three.

| Homework | Complete activity three and share outcomes. | The facilitator gives the learner the full range of responsibilities by removing all assistance. |

Homework: Further activities with or without other families...

Table 10.8: Four-part programme scaffolding process

This gradual transfer of responsibilities is exemplified by the process used to choose suitable projects for family CS Activities undertaken during the ‘Create’ phase during the sessions. Each week the participants have more control over this choice and thereby learn how to curate this selection for the future. The first workshop’s ‘Create’ activity is chosen by the facilitator, the following week the participants get to select out of three provided options and for the final activity they are given a number of websites to explore, further widening the choice. Finally, in workshop four they are given the opportunity to choose a project for a future self-directed session (Table 10.9). A ‘homework’ webpage, developed and maintained by the researcher, is provided to support this process (Figure 10.15).

<table>
<thead>
<tr>
<th>Week</th>
<th>Choosing the ‘Create’ Activity</th>
<th>Supports</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chosen by the facilitator</td>
<td>Facilitator</td>
</tr>
<tr>
<td>2</td>
<td>Chosen by the participants out of three options provided by the facilitator</td>
<td>‘Homework’ webpage (Figure 9) and ‘Selecting a project’ card (Figure 10). Discussion led by facilitator.</td>
</tr>
<tr>
<td>3</td>
<td>Chosen by the participants out of seven websites provided by the facilitator</td>
<td>‘Homework’ webpage and ‘Selecting a project’ card. Discussion led by participants with facilitator support.</td>
</tr>
<tr>
<td>4</td>
<td>Chosen by the participants</td>
<td>‘Selecting a project’ card Discussion led by participants.</td>
</tr>
</tbody>
</table>

Table 10.9: Scaffolding the ‘Create’ activity selection process

The actual selection process is carefully structured and consists of the following steps:

1. At home, families look online at potential activities and use a simple scoresheet (Figure 10.16) to assess their suitability.
2. In the workshop families submit their scores to two child volunteers (thereby involving the children in the running of the workshop) who record them on a whiteboard and announce the results.
3. The top scoring activity ‘wins’ and is selected for the ‘Create’ phase.
Figure 10.15: Screenshot of ‘Homework’ webpage

Figure 10.16: Selecting a project card
10.4.2 Recruitment and Implementation
The four-part programme Design Experiment took place in April/May 2019 across two adjacent DEIS\(^{19}\) primary schools in Dublin - one girls’ school and one boys’ school. Recruitment of the schools was opportunistic with contact made with the schools through the NCCA ‘Coding in Primary Schools’ initiative coordinator. The schools, in turn, recruited interested families. Six families (22 participants) took part, consisting of eight parents, two grandparents, one adult child and 11 children aged 7-12 (six girls and five boys). Facilitation was organised directly by the researcher who was present for all workshops.

Evaluation of the programme followed the same data collection and data analysis process as the one-off workshop previously described in Section 10.1.

10.4.3 Four-Part Programme Findings
The data analysis was again structured around the evaluation research questions. Namely, whether the draft Design Principles were effectively implemented, did this have an impact on the predictor factors, and was there any evidence of a subsequent effect on PI attitudes and/or PI behaviours?

Of the 11 adult participants seven were female and four were male. They included two grandmothers in their 70s, one 19-year-old male child and nine parents (five mothers, three fathers) all in their 40s. Three (two female, one male) reported having some previous computing experience but only one of those had previously done any CS activities with their children at home.

10.4.3.1 Did the Interventions Effectively Implement the Draft Design Principles?
Once again, the adult responses to the questions concerning the perceptions of the workshop in the post-questionnaire were scored from 1 to 5, or from 5 to 1, so that in each case the higher number reflected greater reported more positive perceptions. The mean response for each question is displayed below in Figure 10.17.

\(^{19}\)DEIS (Delivering Equality of Opportunity in Schools) is a national programme aimed at addressing the educational needs of children from disadvantaged communities.
These responses indicated that the draft Design Principles had been successfully implemented. The mean responses to all of the items scored between 4 (‘agree’) and 5 (‘strongly agree’). As with the responses to the one-off workshop, the positive reaction to the opportunities for creativity and the making of a meaningful artefact (DP5) was particularly noteworthy. A marked improvement in support for the statements that the activities related to the families’ interests and for learning about computing was a positive development. This may have been related to the fact that the respondents had more choice over the activities that they engaged in (DP4 eliciting the families’ input) and that they had more time over the four weeks to get familiar with the technologies used.

The qualitative data were again valuable in the evaluation of the implementation of the Design Principles. With regard to DP1: The interventions should be collaborative within families; the observations showed the families working well together. One particular success story was of a family consisting of two children and their grandmother who was initially surprised, and a little upset, by the expectation that she actually get involved. Her reluctance was overcome by the children’s enthusiasm – they insisted that she complete tasks and helped her to get started – and by the final week she was contributing fully and mentioned to the facilitator that she was proud of herself: “I’m 79 you know, but it turns out you can teach an old dog new tricks.”

This pattern also emerged strongly in the Focus Groups with parents reporting how much they appreciated working with their children: “D___ enjoyed using the equipment, the Makey Makey and the micro:bit and I really enjoyed watching him having so much fun”, “I just enjoyed doing stuff with my kids. It was really good fun. We loved it.”.
As well as the participants enjoying working within their families, the observations showed that by week four the inter-family interactions had really increased in both quantity and quality (DP2). As discussed earlier, this was a particular focus of this experiment. A number of design decisions were made to support this, the most obvious being the extended nature of the intervention which meant more time to get to know each other. But, in addition to this, the arrangement of the learning space was a new consideration in the implementation of this experiment. In the one-off workshops each family had gathered around a desk or group of desks and, for the most part, did not move around the room or interact with other families during the ‘Create’ phase. In the four-part workshop the facilitator made sure that there were two families sitting around each set of desks and the families were moved each week so that they were sharing with a different family. Figure 10.18 illustrates this for week four, with participants from each family being represented by the various colours. Another effort to encourage more inter-family collaboration involved strongly encouraging the families to ask another family for help before coming to the facilitator from week two on.

![Figure 10.18 Room layout and family locations week four](image)

While the ‘Icebreaker’ phase in week one served to introduce the families to each other it was observed that it wasn’t really until the first ‘Share’ phase that they began to be comfortable interacting. However the families sharing the desks were engaging in introductory conversations. By week two the families had started to ask each other for help and the children would often just go and have a look to see what the others were up to. Working together to choose the activities sparked a lot of conversation and laughter. By week three some of the more confident adults and children helped with the technical setup (unprompted) and, after the ‘Share’ phase, two of the families went back to their projects.
and made some changes based on what they had seen. By week four the families were facilitating and working really well as a group. Those that finished early went and helped those who were struggling a little with one family commenting “this all makes much more sense when we’re doing it with other families”.

This progress was confirmed by the focus group responses: one respondent reported finding enjoyment in working and celebrating with other families, particularly in the ‘Share’ phases: “I enjoyed looking at some of the games people made and the different code that went into them. Some of them were simple enough and some of them were very complicated but everyone was rightly proud of them”. When asked did they help others or get help from others, one parent commented “I think that was good actually. I think everybody worked collaboratively and that was needed, you know. People had different skills. Some people were into arts and crafts and other had more technical expertise”. An interesting finding was that one family got a particular shout out from the others – this family consisted of a father with previous technical experience and his two sons, one of whom was the only participant with significant Scratch experience. This child was observed to be clearly enjoying his role as troubleshooter for the group which he began in week two. The positive role this family played, and the appreciation the other families expressed for that in the Focus Group, suggested that, while it may not be necessary, it is certainly useful for at least one family in the programme to have some CS experience. In addition, their involvement was observed to increase the group’s confidence that outside facilitation was not a pre-requisite for the activities. How important this observation is to the success of the programme warrants further investigation in future cycles of the research.

The structured nature of the activity model (DP3) also continued to provide support the participants. The plan for each week was carefully explained to the families and the provision of the OurKidsCode Cards was appreciated with all the adults observed to use them. As the families gained more control and the details of each phase were left more up to them, the facilitator made sure that they continued to work within with the activity model but, as they started to choose their own activities it was obviously no longer possible to supply the cards. It was also not desirable to do so as the workshop was designed to encourage more independence and self-reliance. However, in week four one of the less confident families reported missing the detailed step-by-step instructions from week one indicating that the level of scaffolding needed may vary depending on the confidence and ability of the families. Indeed, as control was gradually passed over to the families through allowing them to choose their own projects and take over the facilitation role (DP4), it was observed that the
more confident families led the way at first. However, by week four all but one of the families were contributing fully to the conversations and organisation.

While the plan was for the parents to become more active in planning and structuring the activities as the programme progressed, one of the more surprising observations was both the eagerness and the ability of the children to help organise the sessions. From helping others to complete their tasks to running the ‘Plan’ and ‘Share’ phases they were often to the forefront. It was children who managed the process of choosing the projects by eliciting the scores for the different options and writing them on the scoreboard (Figure 10.19) and they were also the ones who decided how the sharing sessions would work in weeks three and four.

![Figure 10.19 Choosing a project ‘scoreboard’](image)

Adults from four of the six families (two of whom had previous technical experience and two who didn’t) also stepped up and looked after progress from phase to phase and making sure that no one got left behind. Two of the parents ran the final focus group as part of the ‘Reflect’ phase at the end of week four (Figure 10.20).

![Figure 10.20 Parents facilitating the ‘Reflect’ phase in week four](image)
The observations also reinforced the importance of **DP5**, the *use of computers as creative tools leading to the making of a meaningful artefact*. The families began with the ‘Crazy Orchestra’ activity using the laptop cameras and Scratch to ‘conduct’ a band with a baton made from the craft materials. They also used Makey Makeys to complete an interactive drawing project and they fashioned a wearable wristband with a micro:bit which they programmed to play Rock-Paper-Scissors. The children, in particular, clearly enjoyed the making and decorating of their artefacts (Figure 10.21).

![Figure 10.21 Making and decorating a micro:bit wristband](image)

When asked in the Focus Group what they enjoyed, the making and the physical elements were repeatedly cited: “*I liked being able to control things with your hands, it’s pretty cool, you know, rather than having to type thing up its great that you can just interact with the screen... its more accessible as well.*” This pattern continued throughout the programme, once again highlighting the importance of the creation of a physical artefact to the engagement and enjoyment of the participants. The successful demonstration of the fun and creative nature of coding was commented on in the final session by one of fathers: “*I went to college years ago and did a little coding but it was very technical and stuff. I thought this was really visual, there was lots of colour and coordination and there’s a kind of look to the way that you code. There’s still a lot of Maths behind it at the end but it’s like Lego blocks you know.*”

Sharing and celebrating these outcomes (**DP6**) was consistently the highlight of the workshops. In the case of the micro:bit wristband, this consisted of a Rock Paper Scissors tournament run by the children (Figure 10.22). There was much laughter and excitement and when one of the children told us they were going to bring their wristbands to school the following day to show their friends, all of the others decided they would do the same.
In an effort to more fully implement **DP7: Interventions should be structured to include ongoing dialogue about what is being learned. Time should be reserved for collaborative reflection to complete the learning experience**, the design of the programme included reflection on the learning at three points rather than just leaving it to the very end. This enabled the participants to voice their concerns as well as their appreciation of their progress. The details of these conversations have been discussed throughout this analysis but on a more general level when one of the participants noted “it’s nice to know that you’re not alone in finding it difficult and, you know, like... share your experience” there was general agreement from the other adults.

The final ‘Reflect’ phase was run by two parent participants. This conversation was longer and more detailed than the other two and provided richer data. Whether this is because it was participant rather than facilitator led, or because the participants were just more comfortable having spent more time together is unknown.

Finally, as discussed in Section 10.4.1 Programme Design, one of the central goals of the programme was the fostering of self-reliance and the building of a community of practice in order to support ongoing self-directed activity (**DP8**). The participants were explicitly made aware of that goal in the ‘Introduction’ in week one and the scaffolded nature of the activity model, gradually moving control from the facilitator to the participants was observed to operate well in practice as discussed previously.

The addition of the ‘Plan’ phases to the workshops, as well as serving the obvious purpose of selecting projects for the ‘Create’ phase, was observed to help the participants learn how organise workshops and to go about choosing suitable activities. The supporting materials provided for that process were generally completed by the children with the help of the participants.
adults. The programme ended with a final ‘Plan’ phase, facilitated by the parents to discuss potential future activity.

10.4.3.2 Did this have an Impact on the Predictor Factors?
Again, the workshop was analysed for its impact on confidence, creative usage, availability and experience. The pre- and post- workshop questionnaires were examined with the intention of measuring the change in self-reported confidence over the course of the four weeks, Cronbach’s alpha was computed in order to measure the internal consistency of items dealing with the self-reported confidence levels. For all ten items, the value was .903, which is deemed “excellent”. The mean value was calculated, to give a number in the range 1 to 5. This was done for both the pre- and the post- questionnaire.

When it came to comparing the pre-programme and post-programme scores, all 11 of the participants completed the surveys and were included in the analysis. The Shapiro-Wilk tests did not show a significant departure from the normal distribution (W(11) = .941, p = .549); so paired t-tests were then carried out to see if there was a significant difference in the means before and after the programme.

The two sets of self-reported confidence scores are presented graphically in Figure 10.23, with each line representing a parent participant. All but two of the participants returned higher scores at the end than at the beginning of the programme. All the other nine reported an increase in confidence levels. The biggest increase was seen in item 3: I am very confident in my ability to use computers, where the mean went from 2.82 to 3.91. Overall, the mean score rose from 3.15 before to 3.68 after, Results of the paired-t test indicated that there was a significant medium difference between before (M = 3.1, SD = 0.7) and after (M = 3.7, SD = 0.6), t(10) = 3.1, p = .012.

![Figure 10.23 Change in self-reported confidence from pre- to post-programme](image)
While the small size of the sample means that these results are only indicative, they do serve to reinforce the findings of the observations. These recorded clear indications of the parents growing in confidence over the four weeks. In week one they concentrated on following the instructions for the ‘Crazy Orchestra’ workshop on the OurKidsCode Cards and were very reliant on the facilitator to progress through the tasks. In week two, out of the three options provided for them, they chose a project from the Library Makers Website\(^{20}\) which involved creating interactive drawings using the Makey Makey. After the facilitator explained how the Makey Makey worked, the families set to work following the online instructions. However, one of the families departed from the instructions and experimented with the Makey Makey. The facilitator had mentioned in passing that as long as something was conductive (even fruit) you could use it as a controller, and so an uneaten banana appeared out of a school lunchbox (Figure 10.24). The other families, seeing this, joined in the fun and soon apples and oranges were also being employed and incorporated into the project. This willingness to experiment and deviate from the instructions indicated a growth in confidence from week one. It also demonstrated an increased appreciation of the creative usage of technology.

![Participant experimenting with conductive materials](image)

**Figure 10.24 Participant experimenting with conductive materials**

Week four, was fully facilitated by the parents and the families supported each other with no prompting from the facilitator necessary. The impact of CS experience on this process was evident as it was the parents with previous technical experience who took the lead during the ‘Create’ phase. Interestingly, previous experience did not seem to have the same

\(^{20}\) [https://librarymakers.net/interactive-drawings-makey-makey-scratch](https://librarymakers.net/interactive-drawings-makey-makey-scratch)
impact when it came to the children. While, as previously mentioned, the child who had used Scratch before was the first to start helping, the other children quickly joined in and they were observed to be much more likely to help, not because they already knew the solution, but by just getting stuck in and trying things out.

When asked in the Focus Groups if they found the workshops difficult or challenging, the responses clearly corresponded to the previous experience of the participants. Those with that experience found the projects straightforward. Others reported finding it tough in the beginning but, again, reported a growth in confidence as they worked through things: “It took us a while to get going. We did find it difficult at the beginning, but once we got going…” “Yeah, we were the same. I think it’s a little bit daunting at first”. A third family also reported a similar experience of difficulty at the start but this being resolved by the end: “I didn’t understand why I was doing all the things. But it did become clear eventually.” They also commented on how the inter-family support helped them overcome this: “Some people finished early but then they helped so it worked pretty well.”

Whether partaking in the programme increased their CS experience remained unclear. Looking at the responses to the question “Can anyone think of anything that they learnt today that they didn’t know before?” the children generally reported on the specifics of the project: “How to use Scratch”, “You can record sounds on your laptop”. The adults were more reticent here, with one of the participants simply commenting “Everything!”.

The importance of creativity in relation to the engagement and enjoyment of the activities has been discussed above in relation to DPS. When asked in the Focus Groups if the workshop was what they expected, a couple of the adults admitted to not knowing what to expect and the biggest surprise the participants reported was the making element: “I didn’t know we’d have to make stuff; making stuff is fun”, “I thought we’d just be sitting around a computer typing”. This aligns with the observation that at least some of the adults had not been expecting to have to participate so actively but were happy to get involved in creative tasks.

The issue of availability came up in queries about some of the hardware, particularly the Makey Makey and micro:bit. Some of the parents asked where they could source them for their own use and how much they cost. This indicated that they appreciated the opportunities that this type of hardware provided for ongoing family creative computing activities. The project provided these for the workshops and gave each family a micro:bit to take home with them for future projects – a gift which prompted a lot of excitement among
the children in particular. It was hoped that providing these could help support future activity. However, no evidence for this emerged from the follow-up survey. Availability of a suitable location and technical infrastructure also arose when discussing potential future activity; this aspect is discussed in the following section.

The final comments on the programme were extremely positive: “It’s been fantastic, it’s been amazing. For years I’ve been seeing people go to coding workshops and thought what on earth are they doing will I ever be able to do something like that with my children. Done, ticked, brilliant. To try it, really helpful.” “I thought so as well. I thought it was very accessible. It kind of demystifies the whole coding area.”

Even the adults who did not wish to pursue it further expressed their appreciation: “I thought the children did really well and while I didn’t understand everything that was going on, I thought they enjoyed it and got a lot out of it. For that. Thank you very much”.

10.4.3.3 Did this in turn have any Impact on PI Attitudes and/or PI Behaviour?

Analysis of the two items exploring change in future intentions in the post-questionnaire, followed a similar process to the confidence items. All 11 participants responded to the two items. All but one of the participants already either strongly agreed or somewhat agreed pre-programme that they would like to take part in computing activities with their family in the future. Again, this was to be expected given the self-selecting participation in the programme (a limitation which will be discussed more fully in the following chapter). After the programme two participants went from somewhat agreeing to strongly agreeing, one from somewhat disagreeing to somewhat agreeing. However, one did drop from ‘somewhat agree’ to ‘somewhat disagree’. Results of the paired-t test indicated that there was a non significant medium difference between Before (M = 4.1 ,SD = 0.9) and After (M = 4.3 ,SD = 1), t(10) = .6, p = .553. The results are displayed graphically in Figure 10.25 below.

![Figure 10.25 Future intentions](image-url)
Nine out of the 11 participants felt more able to organise family CS activities at the end of the programme with two feeling less able (Figure 10.26). Here the difference between the averages of before (2.45) and after (3.55) is big enough to be statistically significant at the 0.5 level, with results of the paired-t test indicating that there was a significant medium difference between Before (M = 2.5, SD = 1) and After (M = 3.6, SD = 1.1), t(10) = 2.5, p = .029.

![I feel able to organise computing activities with my family at home.](image)

**Figure 10.26 Readiness for future activity**

Again, while the sample size was small and cannot be used to draw any definitive conclusions, this quantitative data provided useful triangulation for the qualitative findings. At the focus group in week one discovering why the participants had signed up to the programme was important. It appeared that this was largely driven by the children’s interest: “*We did some coding in school and I liked it*”, “*It sounded a bit exciting*”, with the adults attending purely for their benefit. In the final focus group the families were invited to consider their future intentions. When asked if they would like to attend a similar workshop in the future while the children were the most enthusiastic: “*I would because it’s fun*”, “*I would because I like coding and it’s fun*”, some of the adults also wanted to learn more for themselves: “*I’d have like to have spent a lot more time on Scratch, just because it was the first time any of us had seen it and it’s brilliant. There’s so much to discover on it*”.

Indeed, adults from four out the six families answered in the affirmative when asked if they’d like to be part of a family coding club. One of the adults with no prior experience laughingly said “*I think we’re better off with others*”. Another observed “*I think it’s good in terms of motivation for the children if there’s other children. And for the adults as well if there’s other adults involved. You’re more likely to do it probably*.” Again, this pointed to the effectiveness
of the inter-family collaboration (DP2). The biggest obstacle for them seemed to be logistical issues like access to a suitable space and broadband, confirming the previous finding about the importance of availability as a factor for PI. The project team had already spoken to the school principal about this so could inform them that the school would provide space and support. When the participants were informed of this, they responded “If the school provides the space, then I don’t see why not”. The adults agreed among themselves to share their contact details (“We can create a mailing list or WhatsApp group”) to discuss it further.

Of the six families involved, a parent from three of the families responded to the follow-on survey, one male and two females. When asked what they recalled learning in the workshop, compared to the respondents who had completed the one-off workshop the answers were more concentrated around the technical skills they acquired: “how to use Scratch”, “using Makey Makey / micro:bit”. This suggests that the longer format may have improved their CS Skills as well as their attitude. With regard to follow-on intentions and behaviours, one reported feeling “very” eager with the other two “quite” eager to engage in further computing activities with their families when they had left the workshops and they all felt “quite” prepared to do so. Two of respondents reported that they did go on to do further computing activities with their family or other families; both involved some work with Scratch. The third respondent cited being “away on holidays for a lot of the summer” as the reason why they hadn’t done anything and, in hindsight the timing of the programme, finishing just before the long summer school holidays when families with young children are often away or enjoying outdoor activities seems likely to have an effect on future activities. However, all were planning future activities: “similar projects”, “more work with Scratch” but were vague about whether this would be just within their own family or with others.

The small number of responses means that we can draw very little conclusions about the effect of the workshop on PI behaviour. However, as the scope of this study is exploratory in nature, these findings are still of interest and will serve to inform future cycles of the research as outlined in Section 12.3.

10.4.4 Conclusions and Implications for Design Principles
While the sample size was small, the findings indicate that the successful implementation of the draft Design Principles had an impact on the predictor factors. In particular, the four-part programme was more successful in encouraging inter-family interaction (DP2) and in inviting participants’ input which seemed to support the growth in confidence among the participants (DP4). Creativity and collaboration (both intra- and inter-family) along with the
celebration and sharing of the outcomes remained key to the families’ enjoyment and engagement in the intervention.

A consideration of the implications of the findings on the draft Design Principles led to a number of modifications. The unanticipated level of the input of the children into the planning and structuring of activities, and the positive contribution of that input, led to the conclusion that it should be made more explicit in the Design Principles. Therefore, DP4 was updated from

**DP4**: Participants’ input should be invited, and their existing knowledge and expertise recognised. They should be given the opportunity to become more active in planning and structuring the activities as the intervention progresses.

to:

**DP4**: Parents’ and Children’s input should be invited, and their existing knowledge and expertise recognised. They should be given the opportunity to become more active in planning and structuring the activities as the intervention progresses.

In addition, the finding that the design of the physical learning environment had a positive contribution to the inter-family collaboration prompted a consideration of the significance of this element to the design. Along with the families’ discussion of the importance of a suitable environment for continuing activity, this led to an increased awareness of the significance of logistics to the success of any intervention. This awareness reinforced the importance of availability as a predictor factor for PI in CS Education as well as expanding its definition to include the availability of suitable spaces to engage in CS Activities and the availability of a technical infrastructure. With this in mind, a new Design Principle was introduced.

**DP9**: Interventions need to consider the availability and design of a suitable learning environment and technical infrastructure for their implementation and for any future ongoing activity.

While the implementation of the Design Principles would appear to have had a positive impact on the predictor factors and there is some evidence for a change in PI Attitudes, the follow-up questionnaires do not provide much evidence for a change in PI behaviour. More research is clearly necessary to explore this matter further.
10.5 Complementary Design Experiment: CPD Workshops

10.5.1 Rationale and Aims

The importance of context to this study has been much discussed in this dissertation. In particular, the effectiveness of the facilitation of the interventions was identified as one of Dede’s ‘conditions of success’ (Chapter 8). As Barab advises “We should not study our designs independent of the ecosystems in which they will be integrated; instead, we should engage stakeholders and implementation facilitators as collaborators whose potential actions can become part of the design in situ” (2014, p. 161). Indeed, collaboration between practitioners and researchers is a core element of DBR (Cobb et al., 2003). While the researchers take the lead in the research and design process, practitioners’ knowledge of the “complexities of the culture, technology, objectives, and politics of an operating educational system” (Anderson & Shattuck, 2012, p. 17) is also a necessary component of both. Rogoff also argues for the need to explore how collaborative learning is facilitated. She points out that these adults’ roles are often only referred to in the background and speaks of them as “hidden collaborators” (1998, p. 721).

In the context of CS Education, Roque and Jain (2018) identified that facilitators play a core role in creating safe learning contexts, and have called for research to further understand the facilitators’ role in assisting families learn computing.

It was therefore decided to ‘interweave’ a complementary Design Experiment to further explore the facilitator role and invite their feedback and expertise. This third Design Experiment consisted of a complementary exploratory study focussed on potential facilitators of interventions designed to support PI in CS Education. In keeping with a DBR study, this focus was “not as subjects to be analyzed, but as partners whose insights and functioning are an essential system component” (Barab, 2014, p. 162).

This section reports on the design of the study, participants, data collection and analysis, and findings. It summarises the key ideas and themes emerging from the facilitator feedback on their experiences, beliefs and practices and it discusses how this data can further inform the development of the Design Principles.

10.5.2 CPD Workshop Design

Roque and Jain (2018) rightly point out that facilitators require a unique skillset which enables them to change roles, empathise with learners, and share experiences and knowledge with the aim of helping others achieve their learning objectives. However, they argue that little is known about what professional development supports facilitators need in
order to provide workshops which encourage collaborative learning through the process of making computing artefacts.

Related work in STEM education has identified that facilitators need particular assistance in developing the confidence to encourage knowledge sharing between groups (Sheridan et al., 2014). While Oliver (2016a, 2016b), in his discussions of facilitation in Maker Spaces, suggests that facilitators need assistance with developing strategies for addressing interdisciplinary questions, and for developing practical experience in ‘making’ through taking part in projects. Roque and Jain (2018) conclude that facilitators need professional development which supports “a tinkering mindset” and helps them to build the skills to help others “pursue their ideas”.

Accordingly, the CPD workshops subscribe to two broad learning outcomes which aim to: (1) give facilitators experience in methods which can be used to encourage and support collaborative learning and (2) equip facilitators with the skills to support the families’ engagement with computing content.

In order to learn how to support collaborative learning approaches, research indicates that facilitators should actually participate in, or experience, such learning activities rather than be lectured regarding their importance (Girvan et al., 2016; D. W. Johnson & Johnson, 1987; S. Sharan & Shaulov, 1990; Y. Sharan & Sharan, 1992). After a brief introduction to the project, including the rationale and the pedagogy, the CPD workshops were therefore structured using the same activity model as the family workshops (Section 9.3). To enable this, facilitators were organised into small ‘family’ groups on arrival and assigned a particular role, with each individual then encouraged to roleplay and work as part of a ‘family team’ to complete the creative computing activities (Figure 10.27). In this way, the workshops were designed to provide a practical, team-based and project-oriented introduction to computing, with the participants provided with the opportunity to observe the process of facilitation as a method for teaching and learning computing according to constructivist and constructionist principles.
Chapter 10. Design Experiments: Implementation and Evaluation

During the ‘Reflect’ phase, Facilitators were asked to reflect upon their learning and to share their experiences as well as to provide input and feedback to improve future workshop offerings.

10.5.2.1 Support Materials

As previously discussed (Table 8.1), the diversity of backgrounds and experiences of potential facilitators raised a particular Design Challenge. Since the workshops could not require the facilitators to have extensive technical knowledge, a need for support materials for the organisation and running of the workshops had been identified.

As well as providing participants with clear stepped instructions for activities along with troubleshooting advice, the OurKidsCode Cards also give facilitators guidelines for running the workshop and provide rationale and background information as well as ideas for follow-on activities. Appendix E gives a breakdown and samples of the cards and a sample facilitator card can be seen below in Figure 10.28.
Chapter 10: Design Experiments: Implementation and Evaluation

The supporting website\textsuperscript{21} containing descriptions of the workshop model, and downloadable copies of the cards and providing support and encouragement for facilitators was also available to those undertaking follow-on activities.

10.5.3 Recruitment and Implementation

Four iterations of this Design Experiment took place over the 2018/2019 academic year (Table 10.10). These took place as part of the OurKidsCode Project (described in Section 8.2 Delivery) in order to train facilitators in the delivery of the one-off workshop. Convenience sampling was used to recruit the participants. The first workshop was with facilitators employed by project partners, the NPC. For the second and third workshops, participants were self-selecting, recruited through the CESI mailing list and other professional contacts. Applicants for the training were asked that they be already be working with families with primary-aged children and have the opportunity to run workshops in a venue and time that such families can attend. They were also required to have undergone Garda vetting in accordance with the project’s Safeguarding Policy. The final workshop was delivered to student teachers undertaking a module in technology and learning at Queens University Belfast on the invitation of the module lecturer.

\begin{table}
\begin{tabular}{|l|l|l|l|}
\hline
CPD Workshop & Location & Date & Participants \\
\hline
Workshop 1 & Microsoft Dreamspace\textsuperscript{22} Dublin & 06/10/18 & 21 NPC facilitators \\
Workshop 2 & Trinity College Dublin & 08/12/18 & 10 Volunteers \\
Workshop 3 & Trinity College Dublin & 16/02/19 & 7 Volunteers \\
Workshop 4 & Queens University Belfast & 30/05/19 & 10 Student teachers \\
\hline
\textbf{Total} &  &  & 48 \\
\hline
\end{tabular}
\caption{CPD workshop participants}
\end{table}

10.5.4 Data Collection and Analysis

While the study more generally explored the role of the facilitator. The findings presented here focus particularly on the further exploration of \textit{RQ2: What principles should inform the design of interventions to support PI in CS Education?} In service of this, a number of research questions were devised to elicit the input of the facilitators into the development of the Design Principles and to explore the implications of the Design Principles for the training and role of the facilitator.

\textsuperscript{21}http://www.ourkidscode.ie/
\textsuperscript{22}https://www.microsoft.com/dreamspace/Home
Chapter 10. Design Experiments: Implementation and Evaluation

- Do the facilitators’ beliefs about teaching and learning align with the Design Principles?
- Does the implementation of the Design Principles support the facilitation of the workshop?

Evaluation of the workshops followed a similar data collection and data analysis process as the family workshops originally described in Section 10.1. Namely, using mixed methods to explore pre- and post- workshop, and post- implementation motivation, belief and implementation variables. Data Collection instruments are outlined below in Table 10.11 and included in Appendix F.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Brief Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-questionnaire (QUAL + Quant)</td>
<td>Captures previous experience, motivation and computing confidence. Contains questions and scales sourced from validated instruments. Issued to participants by email in advance of the session.</td>
</tr>
<tr>
<td>Observations (Qualitative)</td>
<td>Utilises a template to capture observations of participant behaviours during workshops.</td>
</tr>
<tr>
<td>Fieldnotes (Qualitative)</td>
<td>Utilises a template and handwritten notes to capture planning, administration, design, logistics and theoretical issues as well as practical influences which impact workshop delivery and are written prior to and after workshops.</td>
</tr>
<tr>
<td>Workshop Artefacts (Qualitative)</td>
<td>Photographs of artefacts produced during workshops.</td>
</tr>
<tr>
<td>Focus Group (Qualitative)</td>
<td>Audio recorded semi structured conversation exploring learning outcomes as well as motivation and beliefs.</td>
</tr>
<tr>
<td>Post-questionnaire (QUAL + quant)</td>
<td>Captures reactions, learning and future intentions. Issued to participants at the end of the session. Contains questions and scales sourced from validated instruments.</td>
</tr>
<tr>
<td>Follow-up Questionnaire (Qualitative)</td>
<td>Evaluates the adequacy of the training in practice. Emailed to facilitators after a 6-month period (to allow for time for implementation) and includes the option to reflect on post-workshop implementation experiences through a link to an online questionnaire or via email.</td>
</tr>
</tbody>
</table>

Table 10.11 Data collection instruments for CPD workshops

The data collected was predominantly qualitative in nature. As this analysis was exploring the same themes as the family workshops, directed content analysis was again undertaken using the same initial (Table 10.4) and emergent (Table 10.5) codes. The analysis also left
room for data that could not be coded to be identified and analysed to determine if they represented a new category or a subcategory of an existing code. This process was again undertaken with the aid of a Research Assistant from the project team.

For quantitative data the internal consistency of any scales was checked by calculating Cronbach’s alpha and the data was analysed using descriptive statistics and findings displayed using charts.

Finally, text responses from facilitators reporting on their implementation experiences, were analysed by the researcher and Research Assistant in time order, then organised according to the context in which the OurKidsCode workshop model was used. Included in this analysis are direct quotes from facilitators reflecting on their experience, with one facilitator also providing photos of their implementation. These short vignettes provide insight into the practicalities of using the Design Principles in different contexts.

10.5.5 CPD Workshop Findings
The findings present the quantitative analysis of pre (n=41) and post (n=30) workshop questionnaires responses as well as the qualitative analysis of focus group, field notes, and audio-visual content collected from the four professional development workshops. Also included are post-implementation follow up results (n=6) capturing facilitator use of the workshop content with family groups (Table 10.12). Low post-implementation responses are attributed six-month time lapse since last attending the CPD, in order to give facilitators time to implement the content of the workshops.

<table>
<thead>
<tr>
<th></th>
<th>Pre-Workshop Responses</th>
<th>Post-Workshop Responses</th>
<th>Follow-up Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>41</td>
<td>32</td>
<td>6</td>
</tr>
<tr>
<td><strong>Sample</strong></td>
<td>48</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td><strong>Response Rate</strong></td>
<td>85.4%</td>
<td>66.6%</td>
<td>12.5%</td>
</tr>
</tbody>
</table>

*Table 10.12 Total pre- and post- workshop, and follow-up responses*

10.5.5.1 The Participants
The participants formed a sample of n=48 educators who took part in the CPD Workshops over four separate dates (Table 10.13)
Eleven participants had prior computing qualifications ranging from EDCL to M.Sc. level, four of these were at degree level. In addition, the 10 trainee teachers were completing a module on technology in education, and all had prior exposure to Scratch. When it came to programming experience, just over half had never programmed, and only nine reported successfully writing programs before (Figure 10.29).

Table 10.13 CPD workshop participant numbers

<table>
<thead>
<tr>
<th>Workshop Date</th>
<th>Total Participants</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>06/10/2018</td>
<td>21</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>08/12/2018</td>
<td>10</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>16/02/2019</td>
<td>7</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>30/05/2019</td>
<td>10</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>15</td>
<td>33</td>
</tr>
</tbody>
</table>

Eleven participants had prior computing qualifications ranging from EDCL to M.Sc. level, four of these were at degree level. In addition, the 10 trainee teachers were completing a module on technology in education, and all had prior exposure to Scratch. When it came to programming experience, just over half had never programmed, and only nine reported successfully writing programs before (Figure 10.29).

The cohort profiles varied across the workshops. The NPC facilitators in the first workshop had the least technical experience but were all qualified and experienced in facilitation. The volunteers in workshops two and three were the most technically literate but the majority had little educational experience or training, although they included six teachers and two trainers among the 17 participants. The trainee teachers, by definition, had teaching training and they also had a small amount of technical knowledge but had little real-world experience. From a DBR perspective, this variety of experience was considered to be a
positive as it provided an excellent opportunity to evaluate the workshop in different contexts.

When it came to existing levels of computing confidence of the participants, firstly Cronbach’s alpha was calculated to ensure the internal consistency of the scale used to measure this in the pre-questionnaire. This was 0.91 which means that the internal consistency was deemed to be excellent. The average of each participant’s responses (n=41), with higher scores indicating higher confidence, was calculated and this is displayed below in Figure 10.30. This illustrates that the computing confidence levels varied widely among the participants ranging from 2 all the way up to 5.

![Figure 10.30 Facilitators’ confidence pre-workshop](image)

The NPC facilitators were being trained with the intention of providing after-school workshops to interested Parent Associations nationwide. The others were asked in the pre-workshop questionnaire in what context they planned to give workshops and Code Clubs, Homework Clubs, Community Centres and Tech Hubs, in- and after-school contexts and Science Week events were all mentioned.

These findings, the diversity of experience and confidence and the variety of potential implementation contexts, served to confirm what had been identified as a Design Challenge in Section 8.2, namely **DC1: The diversity of backgrounds and experiences of these facilitators means that the workshops must not require the facilitators to have extensive technical knowledge. A need for support materials for the organisation and running of the workshops**
was also identified, both to assist facilitators, and to help participating families solve problems as they encounter them in the tasks.

10.5.5.2 Do the Educators’ Beliefs about Teaching and Learning align with the Design Principles?

This evaluation looked to further explore the efficacy and utility of the draft Design Principles, as implemented in the workshop content and methods, in meeting educators’ theoretical and practical needs in the context of facilitating family computing workshops. It did so by considering what facilitators believed about the approach taken. This was guided by the DBR perspective that the people who are affected should have a stake in the inquiry process. As Barab et al. explain: “Over time, our focus shifted and our team became committed to understanding the participants and their contexts of participation, with the later goal that lessons learned would allow us to develop a more useful product prototype” (2004, p. 255).

The exploration of this question began with an examination of the responses to the pre-questionnaire in relation to the facilitators’ motivation and beliefs before the CPD workshop. When asked why they wanted to attend the workshop most of the n=41 responses to the pre-questionnaire spoke of helping children learn computing skills: “…to encourage other young people to explore the exciting and amazing world of science and technology!”, “…to teach coding skills to a group of young people in the project I work in”. However, a few had picked up on the family-centred nature of the offering: “I researched the project, it looks very interesting, and I feel it would be a huge benefit to families.” “I would like to be able to deliver this training alongside other supports for parents and mentors”. Many were also keen on the collaborative nature of the workshops “I am enthusiastic to help and encourage young people, parents and teachers to have fun learning and creating together”. Another spoke of being interested in “working with, sharing ideas and supporting others”.

The other theme that was identified in these responses was the appeal of creativity: “I like the idea of adding creativity... I have loads of ideas but keeping the content fun for kids each week is the tricky part!” and being able “to support and encourage creative imaginative use of technology as a potential antidote to passive consumption”.

An interesting theme that emerged here was the idea of learning about best-practice; one volunteer facilitator wanted to attend “because I want to go about things properly. I want to use known good approaches as a baseline.” Another had “been looking for
ideas/opportunities to use my technical skills to inspire children via a club/class and this looks to be an ideal way to ensure I'm going about it properly."

These responses demonstrated that at least some of the educators already shared the values around family collaboration and creativity present in the Design Principles (DP1, DP2, DP5). The desire to incorporate best-practice in their work also indicates that the availability of evidence-based Design Principles in itself would be of value to them.

Post-workshop, when asked in the focus group what they enjoyed, the creation of a working artefact (DP5) was clearly important: “I suppose the fun was the delight at the end - we did actually manage it; we did actually do it; we had the eureka moment.” The sharing of that achievement was also identified by many (DP6), with one participant describing it as “really powerful”. The observations confirmed this, recording that the participants seemed to really enjoy that phase of the workshop. It was also noted in two of the focus groups that this sharing and celebration was also a good motivating factor “because that means you have a compulsion to have something that’s nearly there or there... you have an objective”.

However, it was clear from the focus groups, post-questionnaires and the observations that for the educators the most important factor in their learning and enjoyment was the collaborative element. Again and again, they spoke of the value of working in groups (DP1): “The thing I really like about it was the collaborative approach, our group worked very well together.” Figure 10.31 shows two participants working together to complete the Dance Mat activity.

Figure 10.31 Facilitators working together on the Dance Mat activity
The participants also recognised the merit of learning with other groups (DP2) and many instances of inter-group interaction were observed, with participants asking for and offering help and encouragement as well as exchanging ideas. This aspect was noted and commented on in the focus group: “another group came up with that hopscotch idea for their dance. It was great to watch the creativity. It gave me lots of ideas.” The success of the collaboration was also observed by the lecturer of the student teachers after the session with them: “We did more talking, and the groups did more talking then they did all year. They had to, to do the problem solving.”

What also emerged very clearly from these observations was the importance of managing the different roles that members of a group might undertake:

“There was really good teamwork, we all played to our strengths and had something to do, and I think that’s really important when you’re working with coding and computers.”

“I suppose what stood out for me is that I really liked the different roles,... if there are different roles then there is substance for working together.”

“We had lots of different skills in our ‘family’, a musician, a technician... Families will come in with existing skills and existing dynamics.”

The fact that the activity model and support materials included a consideration of these different roles was appreciated by the participants:

“...that idea of “you just do what I say” is completely taken out of it by this exercise, everyone gets a role.”

“I like the family thing, a lot of the time in our activities the parent brings the child and the child participates but the parent just sits back and gets back to their life, whereas you’re trying to encourage everyone to be part of the activity, we had no choice but to and it was fun and I think that was a nice part of it.” [emphasis added]

This finding of the importance of roles aligns both with the previously discussed literature on Communities of Practice (Section 7.2.2.2) and the identification in related work of the importance of roles in the development of such communities (Section 9.2). While these findings had been incorporated into the design of the workshop, its strong emergence in the analysis suggested that a more explicit recognition of this factor should be included in the Design Principles.
10.5.5.3 Does the Implementation of the Design Principles Support the Facilitation of the Workshop?

The constructivist approach adopted did cause some difficulties with some of the facilitators who had not encountered it before either as facilitators or learners. This was particularly true of the n=21 professional NPC facilitators in workshop one who were more used to behaviourist methods of teaching: “Oh, god, I have to go out and teach it, and I can’t fix this and, how am I going to fix this for somebody else”. However most of these participants came to a better understanding of the role expected of them by taking part in the workshop: “We are so used to going and learning a programme going out and delivering it. I think we have just got to accept that actually this is a bit of a different thing in terms of how we do things and even if you can program, this is different.” Another spoke of learning about the value of “the struggle”: “So, so to make sure that even, to encourage that, you know, so that when something goes well or if it doesn’t - you came over at one stage and said ‘struggle is part of it’ and I think that when the family know that, it is in that trying to work that out that they say it’s ok for us to struggle to understand, so it gave us permission to kind of think about it and [take] a little risk - see what happens when you do this, you know?”.

On the other hand, quite a few of the participants reported really appreciating the approach; when asked in the focus group what learning they would take away with them, one of the volunteers summed this up well:

“What I learned today was to try to be the ‘guide on the side’ rather than ‘the sage on the stage’ and I really enjoyed it. I kind of knew it, but I forget, you really just have to do it yourself, to get down and sort it out, it’s discovery learning. I just loved being in the middle actually doing the stuff rather than walking around telling people what to do. It was fun!”

In the post-questionnaire, another stated that being “comfortable with people struggling and reflecting on how this is part of coding and learning by doing” was the key learning that she took from the day.

The structured nature of the activities (DP3) was commented on by a number of the participants as being of value for the facilitation of the workshop along with the usefulness of the supporting OurKidsCode Cards: “I think with the cards, having that material, it means there’s no fear of not being able to do it.” When asked if they were happy with the structure, there was general agreement that it worked well. One participant did suggest that a short time (“three minutes”) should be added for talking through the activity and planning it before the ‘Create’ phase. This would also have the benefit of supporting more ongoing
dialogue and reflection (DP7) and giving more time for a consideration of roles for that phase.

When the post-questionnaire asked ‘What new methods were you taught and how do you plan on adapting these to your teaching?’, again the value of the structure was evident with participants noting the “importance of a framework and roles”. The inclusion of icebreaking and sharing phases was mentioned, and the usefulness of clear instructions: “Having step by step instructions - together with the reasoning and how to divvy up the jobs for participants, this is really useful, saves having to think about these things last minute.”

When asked to what extent was taking part in the workshop useful and if it helped them as a facilitator, the participants strongly agreed. In particular, they reported that it helped them to figure out some of the practicalities: “It was great to see the dynamic, how the groups work. Then you can think to yourself, I think I could handle, say five groups of four in a room. I can see how much space you physically need; you need long cables...”. They also appreciated the fact that it alerted them to potential difficulties: “Running the workshop and seeing what problems others run into. It was fantastic.” “It was actually good to do the workshop so we could see what can go wrong.”

The participants also considered some of the barriers to delivery, a lot of these were logistical. The cost of materials, suitable locations and times, and access to resources and equipment (all of which could be categorised as computing availability) arose as potential difficulties. A number were also worried about the recruitment of parents: “I could definitely see it being used in school with the student but trying to get parents involved as well could be trickier.” However, the participants also offered solutions to these problems. Simple things, like running the sessions later in the evening to accommodate working parents and the fact that libraries and schools often provide venues and equipment for free, were noted.

One participant pointed out that “for Coderdojo the parents have to be there anyway if their child is under 12 so they’re there anyway”. These discussions reinforced the decision to include a new Design Principle around the factor of availability dealing with practical issues of a suitable venue and availability of a technical infrastructure.

10.5.5.4 Follow-on Activity

Responses to the follow-up questionnaire were examined to further explore the questions by looking at what elements of the workshops educators used in practice. While the low number of responses limit the generalisability of the findings, the richness of the data
allowed for the building of a thick description and provides useful learnings for future research cycles.

Participants were asked to report on the number of workshops delivered, as well any reported use of workshop materials or ideas. They were also requested to share their future plans with regard to organising future computing workshops with families. The following accounts were collated from six former CPD participants responses collected in October 2019 and are organised according to the order received. Each example explores the implementation of a workshop, underpinned by the Design Principles, in an out-of-school context.

10.5.5.5 CoderDojo Context

The first facilitator was a male CoderDojo mentor who had run a family computing workshop using the Makey Makey with three families with children aged from 9 to 11. The facilitator reflected that the “all the kids had enjoyed it;” “they each liked different aspects of making the dance mat” and that “they understood the circuit part very quickly” however “the music part (creating a tune)” took longer. Again, this points to the benefits of the making element (DP5) and having different roles for members of the group. He also reported that working as families encouraged collaboration (DP1) and “it did promote the group experience - a definite plus in my book.” The workshop resources also played a key role in enabling families to work independently of the facilitator: “the cards helped them to complete the exercise” however “we only had one Makey Makey so we couldn’t run more than one group at a time.” This meant that there was little in the way of inter-family collaboration. Once more this points to computing availability being a factor in supporting PI. The facilitator was planning further family activities, intending to “try the micro:bit cards the week after next” which indicated that overall he was happy with the model.

Our second facilitator was a female CoderDojo mentor who had delivered a further family computing workshop. They had organised a mid-week session and “19 kids attended (I didn’t count the parents)!”. Analysis of the twitter feed generated from the session23 (also Figure 10.32) shows families working together to complete the Dance Mat activity.

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23 https://twitter.com/CoderDojoDL/status/1131266136245506048
The facilitator shared their reflection on the session: “I would definitely do it again; whereas some parents are good at tech, for those who aren’t, it’s a great way for them to see something cool that they can do with their child, and I believe this would help foster an interest in their child’s continuing progress at CoderDojo. Non-techy parents are sometimes inclined to sit back and let their child learn while the parents then get left behind. I think the OurKidsCode workshops help bridge that gap.” This demonstrates an agreement on the importance of intra-family collaboration (DP1) and creativity (DP5) in the fostering of Pi in CS Education. The educator also planned more activity: “We will be starting a new term in a couple of weeks, and I intend to run the OurKidsCode workshop with some of the newbies”.

10.5.5.6 Foróige Context

Foróige run volunteer-led clubs and staff-led youth projects with over 50,000 young people aged 10-18 in Ireland each year. The third facilitator was a male Foróige facilitator who “did two workshops during Foróige summer camps, one with micro:bits and one with the Makey Makey.” Both workshops were organised as part of summer schedule and the facilitator “had 15 kids with parents at both workshops... during our Science and Discovery summer

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24 https://www.foroige.ie/
The workshops were reported as successful with the facilitator reporting planning more “yes now that we have purchased a couple of Makey Makeys, we are planning to run workshops with other groups in Foróige”.

Furthermore, the facilitator reported that he planned to run further workshops using the Activity Model: “we have designed a third workshop which just uses Scratch to avoid the expense of extra hardware. We haven’t got the cards online yet, but I’ll let you know when they’re ready.” This was really exciting news, as it meant that an educator was able to use the model while working out the details of their own activities within the phases. This is potentially of huge value to the implementation of DP8, encouraging the pursuit of further activity. It also points to the sustainability of the model and its value apart from the particular activities evaluated in the Design Experiments.

The same facilitator shared future plans adding that “at the moment we don’t have any firm numbers as our clubs don’t start back until the middle of September, we are also looking into funding for a tech-hub in our centre which will help with the workshops”. As well as registration and funding, resources were identified as impacting further sessions: “we are hoping to offer the workshops to all our clubs with either myself facilitating them or showing the club leaders how to facilitate the workshops”.

10.5.5.7 After-School Computing Club Context

Another perspective was provided by one facilitator who ran a family computing workshop as an after-school session in her children’s school. This female facilitator shared that “yes - I used OurKidsCode material and ideas as part of an after-school Computer Club at our school”. The session had “Approximately 15 students, together with some parents, once a week take part in the Computer Club”. Once again, future sessions were planned, with the facilitator adding that “yes - the Computer Club will be starting again in two weeks’ time.” In terms of the use of the content and methods, having a structured activity (DP3) was appreciated along with the creative making element (DP5) with the facilitator reporting that “the Makey Makey material worked well, helped considerably by having the printed cards containing all the instructions.”

10.5.5.8 Home Context

A further facilitator reported that they had run a workshop in a home context. This mother confirmed that “I have shared the project with my daughter and we have used the materials provided to do all of the assignments”. She planned to run another session in a nearby public library: “I have a plan to offer the workshop in our local library in W______ on a Saturday
morning over the coming months”. She continued: “the issue of technology in general as a source of negative tension - also in my household - is a subject I wish to address. To be able to shift more towards creative projects and social engagement rather than isolation among children – is the question. How to cultivate and sustain positive habits. I don’t know that it is enough to start something - the question of how to sustain and invite creativity is an important one.” These comments demonstrate the challenge of creating positive learning experiences which are creative and engage parents and their children. This parent also suggested that the creating a competition for “children’s projects to be recognised in some way” would be a good idea showing a recognition of the importance of sharing and celebrating (DP6). She also suggested the creation of “a club or something - with a newsletter to support and share developments” for motivation and to keep connected which showed an interest in implementing DP8, encouraging further activity.

10.5.5.9 Time Restrictions
Finally, the last of the respondents shared the challenge that the scheduling time to implement a workshop was difficult, adding that “unfortunately I didn’t get a chance to put it into practice. Time got away from me. I do hope to do something this year but as of yet I don’t have anything definite”. It is important to include this response, as scheduling workshops was a key factor experienced by other facilitators, with plans for future workshops described but also accompanied with the lack of defined schedule. Finding the time for continuing activity was also an issue for the family workshop participants.

10.5.5.10 Follow-on Activity Conclusions
These vignettes indicate that the Activity Model, underpinned by the Design Principles, could be implemented across a variety of non-formal computing education contexts with all five of those who facilitated a workshop reporting it to be successful. Furthermore, facilitators reported on the usefulness of the teaching materials, particularly the OurKidsCode Cards. More workshops were planned by all of the respondents in the interest of encouraging future activity. The fact that one of the facilitators was developing their own workshop in accordance with the model was particularly encouraging here. A further theme which emerged from the analysis of implementation accounts, was for the need to put in place supports to help facilitators keep in touch with each other as well as for families to showcase their work. The final question asked whether the facilitators would be interested in taking part in further professional development sessions, all six answered in the affirmative.

While the response rate was low, the findings give an indication of the scope and range of contexts which are compatible with the model. They also provided some further evidence
that the Design Principles can support the facilitation of the workshop in practice and that the principles are compatible with the educators’ beliefs and motivations.

10.5.6 Conclusions and Implications for Design Principles
The complementary Design Experiment explored the facilitators’ experience in the design and delivery of interventions to support PI in CS Education. Their knowledge of the complexities of implementation across different educational ecosystems provided a rich opportunity to explore how the Design Principles might work in context. The data analysis was focused on RQ2: *What principles should inform the design of interventions to support PI in CS Education?* And so looked to the data to evaluate the utility and efficacy of the draft Design Principles in supporting such interventions. This was done by looking at the educators’ beliefs about teaching and learning, both pre- and post-training to explore how they aligned (or not) with the Design Principles. The analysis also explored whether the educators believed that the implementation of the Design Principles supported the facilitation of the workshop. Whether the workshops have the desired impact of improving PI in CS Education was beyond the scope of this evaluation.

The facilitators were strongly supportive of the collaborative nature of the workshops, both intra- (DP1) and inter- (DP2) family. They particularly appreciated the way in which the design of the workshops ensured that there were different roles for family members to play and that everyone needed to be involved in order for the task to be completed. The importance of this in supporting the building of a community of practice encouraged the addition of ‘and include suitable roles for different family members to play’ to DP1. Unsurprisingly, as the CPD workshops dealt with the one-off workshop, co-creation (DP4) did not emerge as a theme. This reinforced the need to explore how intervention designs could better support this principle in Design Experiment 2.

DP3 which outlines the importance of structure was of particular importance for the facilitators, especially given their diverse computing and facilitation experiences and confidence levels. Materials such as the OurKidsCode Cards were found to help support this structured approach and the reported use of the Activity Model to design a new workshop by one of the facilitators was an exciting development. Creativity and the sharing of the outcomes of that creativity (DP5 and DP6) were seen as crucial to enjoyment and engagement in the workshops; this reinforced the findings from the family workshops. While reflection (DP7) did not emerge strongly as a theme, the suggestion by one participant to take some time before the ‘Create’ phase to discuss the activity gives an idea about how to build more ongoing dialogue into the model. The follow-on survey suggested that the
facilitators were keen to encourage ongoing activity (DP8). As well as being willing to organise and facilitate this, they also made other suggestions for how this could be supported, such as competitions and the establishment of a community for the facilitators. Consequently, an amendment to DP8 which added ‘and support’ reflects this finding that facilitators value supports for ongoing activity for both the families and themselves.

The constructivist approach to the facilitation of the workshop did cause some initial difficulties with some facilitators more used to traditional modes of teaching but for the most part these were overcome by the end of the CPD workshops. In addition, the facilitators also reported potential barriers, to using the model. These were mostly practical issues such as access to reliable technology and suitable venues as well as finding a suitable time for families to be available. This confirms the importance of the addition of DP9 (discussed in Section 10.4.4) which covers availability as a consideration for the design of such interventions.

Overall, though there are limitations to the study (discussed more fully below in Section 11.4), the insights and expertise of the educators added depth to our understanding and was of immense value to the research, with the findings generally indicating that the Design Principles had potential to support the design and implementation of interventions to improve PI in CS Education.

10.6 Chapter Summary

This chapter described the implementation and evaluation of three Design Experiments: The one-off workshop, the four-part programme and the complementary CPD Design Experiment. and included a consideration of the implications of the findings of each of these for the Design Principles. A full discussion of all three Design Experiments and how their findings have addressed the research questions is contained in the following chapter.
11. Design Experiments: Discussion

11.1 Introduction

The Design Experiments were primarily undertaken in order to explore RQ2: ‘What principles should inform the design of interventions to support PI in CS Education?’. The investigation of RQ1: ‘What factors have an impact on parental attitudes towards PI in CS Education?’ undertaken in Chapters 4, 5, & 6 of this dissertation had concluded that increasing parents’ own computing confidence may have a positive impact on parental attitudes towards, and motivation for, involvement with their children’s CS development. Other factors that were identified as predictors of PI are parents’ programming experience, computing availability and usage of technology for creative purposes. These conclusions, along with the literature review findings in Chapter 7, led to the development of draft Design Principles for interventions to support PI in CS Education (Table 7.1).

In accordance with the DBR approach then, the creation of the interventions was informed by relevant literature, theory, and practice from other contexts; it continued with an assessment of the local context; and was designed specifically to overcome the problems identified and create an improvement in local practice (Anderson & Shattuck, 2012, p. 16). Findings from this were supplemented by a learner requirements analysis relating to the target participants’ baseline levels of computing confidence and experience, as well as details of their computing usage and availability. A review of the design of related work was also undertaken. All this provided a further evidence-base and was used, along with the theoretically-grounded draft Design Principles, as the foundation for the intervention design in the form of family creative coding workshops. The interventions were implemented and evaluated as Design Experiments with the aim of further refining and developing both the Design Principles and the workshops themselves. Their findings also provided a further opportunity to explore the relationship between parents’ own computing behaviours and attitudes and their attitudes towards PI in this domain (RQ1). The previous chapter provides a detailed discussion of the implementation and evaluation of the Design Experiments along with a presentation of their findings. This chapter explores the implications of those findings for RQ2 including a presentation of the refined Design Principles. It also discusses how those findings add to the consideration of RQ1. The limitations of the experiments are then outlined.
11.2 The Design Experiments and RQ2

The first experiment began with the design of one-off workshops which were evaluated over three iterations. Analysis focused on RQ2: ‘What principles should inform the design of interventions to support PI in CS Education?’ and looked to evaluate the effectiveness and utility of the draft Design Principles (Table 7.1). Findings informed the design of the second experiment, which implemented a four-part programme of workshops. Alongside these two experiments, a complementary exploratory study was undertaken with potential facilitators as a result of the recognition of the importance of this role to the success of any intervention.

The generally positive findings of Design Experiment 1 indicated that the workshop design effectively implemented most of the identified Design Principles. There was also evidence that this did have an impact on the predictor factors and led to an increased parental readiness to take part in family computing activities. However, inter-family collaboration (DP2) was lacking and a need for more opportunities to involve families in the planning of activities (DP4) emerged. In an effort to rectify this the second Design Experiment took the form of a four-part programme with increased opportunities to increase parental competence and self-reliance (DP4) and more time and opportunity to encourage inter-family collaboration (DP2).

The evaluation of Design Experiment 2 found that it had been more successful in promoting the desired inter-family collaboration and had also effectively invited the participants’ input into the workshops. The finding that a surprising amount of this input was from the children, and the positive impact this was observed to have on the workshops, led to a refinement of DP4, where ‘Participants’ input’ was amended to ‘Parents’ and children’s input’ in order to explicitly recognise and encourage this.

The Design Experiment also prompted a new consideration of the physical learning environment. On a basic level it was observed that the seating arrangements had an impact on collaboration. But in addition, the improvement of the inter-family collaboration led to a discussion on the continuation of activity where the issue of the availability of a suitable space with an adequate technical infrastructure arose. The importance of this was reinforced by findings from the complementary Design Experiment where facilitators also brought up the issue of availability and access as a potential barrier to implementation. Indeed, these findings complemented the survey finding that computing availability could have an impact on PI and led to the addition of a new Design Principle DP9: ‘Interventions
need to consider the availability and design of a suitable learning environment and technical infrastructure for their implementation and for any future ongoing activity.’

The complementary Design Experiment, with facilitators as participants, brought a new perspective to bear on the Design Principles. Again, overall the findings supported their value, and both complemented and expanded on the findings of the previous experiments. The analysis of this data resulted in two further refinements. Firstly, a strong appreciation of the importance of designing suitable tasks and roles for different members of the family group for successful intra-family collaboration led to the addition of the clause ‘and include suitable roles for different family members to play’ to DP1. The second amendment reflects the finding that facilitators value supports for ongoing activity for both the families and the facilitators themselves. It took the form of adding ‘and support’ to DP8.

In response to RQ2 then, the final set of Design Principles that should inform the design of interventions to support PI in CS Education are presented in Table 11.1 below with refinements and additions in bold.

<table>
<thead>
<tr>
<th>DP</th>
<th>Principle</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP1</td>
<td>The interventions should be collaborative within families and include suitable roles for different family members to play.</td>
</tr>
<tr>
<td>DP2</td>
<td>The interventions must bring multiple families together to encourage inter-family support and communication.</td>
</tr>
<tr>
<td>DP3</td>
<td>The interventions should consist of structured activities.</td>
</tr>
<tr>
<td>DP4</td>
<td>Parents’ and children’s input should be invited, and their existing knowledge and expertise recognised. They should be given the opportunity to become more active in planning and structuring the activities as the intervention progresses.</td>
</tr>
<tr>
<td>DP5</td>
<td>The interventions should use computers as creative tools and lead to the making of a meaningful artefact.</td>
</tr>
<tr>
<td>DP6</td>
<td>The outcomes of the intervention should be celebrated and shared.</td>
</tr>
<tr>
<td>DP7</td>
<td>The interventions should be structured to include ongoing dialogue about what is being learned. Time should be reserved for collaborative reflection to complete the learning experience.</td>
</tr>
<tr>
<td>DP8</td>
<td>The interventions should encourage and support the pursuit of further activity, as a family unit or along with other families.</td>
</tr>
<tr>
<td>DP9</td>
<td>Interventions need to consider the availability and design of a suitable learning environment and technical infrastructure for their implementation and for any future ongoing activity.</td>
</tr>
</tbody>
</table>

Table 11.1 Design Principles for the design of interventions to support PI in CS Education
11.3 The Design Experiments and RQ1

While the evaluation of the Design Experiments focussed on exploring RQ2, they also served to triangulate and complement the findings of the survey (Chapter 6) with regard to RQ1: What factors have an impact on parental attitudes towards PI in CS Education? During the first design experiment, the focus groups, in particular, gave further insight into the factors that were identified as having an impact on parental attitudes towards PI in CS Education, namely confidence, creative usage, experience and availability. Responses continued to indicate that if parents gain computing confidence, through working alongside their children on creative and collaborative projects, they report a more positive attitude to and greater motivation for PI in CS. This includes parents with little technology experience, while parents with more experience of technology also expressed satisfaction in the shared activities.

The second design experiment provided an opportunity to explore these factors further. The importance of confidence was reinforced through the observations of the adults; as their confidence grew over the four weeks, their participation in the activities increased. The participants also experimented more as the weeks progressed. The pre- and post-questionnaires confirmed that their (self-reported) levels of confidence increased. It was also clear that computing experience had an impact on the level and type of participation, with the families who had reported some previous experience taking the lead in troubleshooting activities. However, families with no previous experience were happy to take charge of non-technical aspects of the workshop such as choosing the next activity or facilitating the ‘Share’ and ‘Reflect’ phases. When it came to usage, the findings of this experiment also strongly supported the employment of creative collaborative activities as a major factor in promoting enjoyment of and engagement with family computing.

Availability and access emerged as a concern for parents when they considered potential future activity. This included availability of hardware and high-speed broadband, but also the issue of a suitable physical learning environment. Issues over availability were also raised as a potential barrier to further PI by the facilitators during the complementary Design Experiment. The findings of which also strongly supported the value of the collaborative creative usage.

Overall, the Design Experiments corroborated the quantitative findings of the survey (Chapter 6) while also providing a richer understanding of the meanings, contexts, and processes involved in these factors.
11.4 Limitations of Design Experiments

At the beginning of this research, one aim was to identify the desirable attributes of interventions with the potential to effect positive change on PI in CS Education. This exploratory study provides some initial evidence that the Design Principles described fulfil that objective, but some caveats exist. Common quality issues in mixed methods and DBR research and efforts made in the research design to mitigate these have already been discussed in Section 3.7. This section will discuss limitations that relate to these, that arose in the implementation of the Design Experiments. These include sample selection, sample size, and potential bias in data collection and analysis.

11.4.1 The Sample

It is important to note that the total number of parent participants (n=29) was small and largely self-selecting and it cannot be assumed that the results would generalise to other groups. However, as previously discussed (Section 3.7.3), in DBR studies, it may be more appropriate to speak of ‘transferability’ or ‘replicability’ than generalisability. The research design sought to achieve this by collecting data over multiple iterations of the workshop with different and diverse cohorts. This was also done in an effort to provide, what Denzin and Lincoln (2011) have termed, stability of observations, i.e. whether the researcher would have made the same observations and interpretation of these if they had been observed at a different time or in a different place. Findings were remarkably consistent across the iterations.

Similarly, the facilitator sample (n=48), while modest, was also diverse in reported experiences and provided a richness of data that was immensely valuable in exploring the concepts under study. Their reporting on their own experiences, challenges, successes and beliefs served to triangulate, develop and expand the findings from the family workshops (R. B. Johnson & Onwuegbuzie, 2004). However, the follow-up study could only capture initial reactions from facilitators on their own experiences of trying to implement the workshops and the researcher is not currently in a position to know whether participation in further activities was sustained.

While the quantitative findings are not generalisable, as Anderson and Shattuck’s systematic review reveals, this is consistent with most DBR studies, which unlike quantitative studies, do not produce measurable effect sizes that demonstrate “what works.” Instead, they contribute to the research’s understanding by providing triangulation for the “rich descriptions of the contexts in which the studies occurred, the challenges of
implementation, the development processes involved in creating and administrating the interventions, and the design principles that emerged” (2012, p. 17). In addition, Leppink et al. (2016) advise that replication studies can be a partial solution in such cases as a series of studies, such as those conducted here, generally provides more accurate estimates than a single study, particularly when dealing with small sample sizes.

11.4.2 Data Collection and Analysis

Much of the data collection relied on the use of self-reporting, which, as previously discussed in Section 6.4, carries the risk of response bias. It was beyond the scope and purpose of this cycle of the study to, for example, measure the learning of CS skills; families were not formally evaluated on their coding abilities before or after attending the events. While such assessment may have been helpful in understanding what kinds of learning could be gained from the collaborative coding experience, this study was focused instead on parents’ perceptions of their coding interest and confidence and how this related to PI attitudes and behaviours rather than objective skill measures. Triangulation of the self-reported data with observations and fieldnotes along with follow-up surveys to ascertain any changes to behaviour were employed to mitigate this, however response rates for the follow-up surveys were particularly low leading to a limited ability to track any behavioural changes. Further research focussing on the longer-term impact on PI attitudes and behaviours planned for future cycles of this study (see Section 12.3 Future Research) is clearly needed to corroborate and expand on the initial findings.

The data collection and analysis design looked to manage researcher bias through its implementation of Barab’s framework as described in Section 10.2, and the validity procedures summarised in Table 3.4. However, the data collected may still have been influenced by the researcher’s positionality. Therefore, a number of strategies were employed to maximise inter-rater reliability (whether another observer with the same theoretical framework and observing the same phenomena would have interpreted them in the same way (Denzin & Lincoln, 2011)). Some examples include the collection of the observations and fieldnotes being conducted by the researcher and at least one other person using a template, coding schemas being employed and qualitative analysis being conducted by the researcher and one other with discussions resulting in inter-coder agreement.

Finally, while much effort has been made to maximise the rigour of this research, it should be once again noted that this is limited by the scope of the study which is exploratory in nature (Section 3.4.2) and further investigation of the findings in future cycles of the
research is clearly necessary. How some of these limitations will be addressed by future research will be outlined in the following chapter along with a further discussion of how the aims of the research were addressed.
12. Discussion and Conclusion

12.1 Introduction

The value of PI in children’s education is well established. There is also evidence that the quality and quantity of PI can be improved by well-designed interventions. However, PI in CS Education provides a particular challenge for parents; their educational experience often dates from before the recent resurgence of CS Education at K12 level and they therefore feel they lack the skills and resources to support CS learning. This is also a challenging area for researchers and practitioners as there is a lack of available research to support best practice in the provision of suitable PI supports and interventions.

The research described in this dissertation looked to address these problems by providing evidence-based support for the design of such interventions. Specifically, it aimed to:

- identify factors that have an impact on parental attitudes towards PI in CS Education;
- develop and validate a corresponding research instrument to measure these factors;
- develop a set of Design Principles for interventions targeting these factors in order to have an impact on PI in CS Education;
- develop model interventions that conform with these Principles and explore whether participation in such activities has the potential to improve the quality and quantity of PI in CS Education.

In order to realise these aims, two primary research questions needed to be examined:

**RQ1:** What factors have an impact on parental attitudes towards PI in CS Education?

**RQ2:** What principles should inform the design of interventions to support PI in CS Education?

These questions were explored sequentially with RQ1 addressed first. Drawing on prior analogous research, consultation with experts, and the development of and analysis of responses to a validated survey instrument, the research investigated how parents’ own computing attitudes and behaviours can impact attitudes to and motivation for PI in CS Education. Findings identified confidence, availability, experience and creative usage as predictor factors and provided a strong rationale for the argument that these factors should be targeted by any interventions.
Building from this, the second phase of the research sought to explore how these factors could be targeted effectively. This involved an exploration of RQ2 and began with a literature review to identify appropriate pedagogy which resulted in a set of draft Design Principles. A learner-requirements analysis and review of related interventions further supported the design of model interventions based on those Principles. These were then evaluated through a series of Design Experiments to explore if, firstly the model interventions had implemented the Design Principles, and if this did have an effect on the predictor factors identified in the survey. In addition, the experiments looked to see if the interventions had any impact on PI attitudes or behaviour. Overall, the findings indicated that the use of the Design Principles resulted in the development of a model for interventions that was effective at targeting the predictor factors. They also provided a richer understanding of how targeting these factors may have an impact on PI attitudes and behaviours. The analysis also resulted in some refinements and additions to the principles. The final version of these directly addressed RQ2 and are presented in Table 11.1.

The scope of the research and its positioning as the exploratory cycle of a larger DBR project meant that the findings are subject to some limitations. Including, most notably, the self-selecting nature of the samples and the modest sample sizes. The impact of this was exacerbated by COVID19 and the effect of its attendant restrictions on data-collection.

The following section outlines how the examination of the research questions contributed to the achievement of the research aims.

12.2 Addressing the Research Aims

The following sections address each of the research aims in turn. These will be followed by an outline of plans for future research and possibilities for other related strands of research, prior to the conclusion of the dissertation.

12.2.1 Identification of Factors

The first aim was to identify factors that have an impact on parental attitudes towards PI in CS Education. As previously discussed in Section 2.5, PI is an extremely complex area, and general barriers and predictors, e.g. socio-economic factors or gender factors, have been well researched but are outside the scope of this study. However, a literature review revealed a lack of empirical research investigating how parents’ computing attitudes and behaviours impacted on their attitudes towards and motivation for PI in CS Education. The survey findings identified a number of factors, including parents’ computing confidence, programming experience, computing availability, and the usage of technology for creative
purposes. The Design Experiments served to triangulate these findings and provided a richer understanding of the meanings, contexts, and processes involved, indicating that if parents gain computing confidence, through working alongside their children on creative and collaborative projects, they report a more positive attitude to and greater motivation for PI in CS.

It is envisaged that this understanding will be of practical use in the design of initiatives to address issues of PI in CS. As a result of the understanding gleaned through this research, it can be argued that any interventions intended to improve the quantity and quality of PI should give consideration to access and availability issues and be designed to increase parents’ own confidence and experience, particularly in relation to creative uses of technology.

12.2.2 Instrument Development

Goodall & Vorhaus’s review of best practice in parental engagement emphasises the importance of “understanding what parents already do with their children and how they are most likely to respond positively to attempts to engage them (further) in their children’s learning” (2011, p. 7). In the case of CS Education, this understanding is currently lacking. Previous research (McGill et al., 2019) identified a lack of evaluation instruments for PI constructs in the realm of CS Education. In order to help identify the predictor factors discussed above, it was therefore necessary to develop and systematically validate a survey instrument. Overall, it can be argued that the validity and reliability of the developed scales established in Chapters 5 and 6 is sufficient evidence for the use of the instrument in future research into PI in CS Education.

The survey’s potential contribution to evidence-based design should assist both practitioners and researchers by allowing them to gather quantitative data in a reliable manner. This has a number of potential applications: firstly, as a single test it can be used for gathering data to discern the level and form of assistance parents require and, secondly, as a pre- and post- test it can be deployed to evaluate the impact of such supports. The data thereby gathered can provide triangulation for qualitative data and also provide consistency across multiple studies and contexts in the domain.

12.2.3 Design Principles

A set of draft Design Principles, embedded in appropriate pedagogy, were generated to facilitate the design and development of interventions to support PI in CS Education. These aim to target the predictor factors identified through the examination of RQ1, in particular
looking to increase parents’ confidence and skills in the creative usage of computing, while at the same time providing educators with a structured approach to collaborative family learning.

The principles were subject to iterative testing and refinement through the design and evaluation of a number of interventions or ‘Design Experiments’ that adhered to them. This process allowed a broad examination of the impact of implementing the principles and led to amendments and refinements. While exploratory in nature, the evaluation provided some evidence to demonstrate that participation in activities developed in accordance with these Design Principles has the potential to increase parents computing confidence and also has a positive initial impact on their PI Attitudes.

12.2.4 Workshop Models, Activities and Resources

In accordance with the underlying Pragmatic philosophy of this research and in keeping with DBR’s commitment to the real-world application of theory, the workshop Activity Model, along with the three one-off workshops and the four-part programme and their associated supporting materials have been made freely available to educators and parents who wish to use them to encourage and support PI in CS Education. As part of the OurKidsCode project, a further 15 facilitators have undergone training since the initial 48 facilitators have been trained and more training sessions will take place before the end of 2022. Despite difficulties caused by COVID-19 restrictions, by the end of 2022, over 100 of these one-off workshops will have been delivered online via the National Parents Council Facilitators and others, along with 68 workshops as part of the pilot four-part programmes across seven counties in Ireland.

Further expansion of the programme is planned for 2023. A partnership with the Department of Rural and Community Development (DRCD) will see the rollout of the programme to 24 counties by the end of 2024. This partnership aims to address the issues of access and availability identified by this research. The location for these will be community Broadband Connection Points (BCPs), these are c.300 public locations in local communities throughout rural Ireland which have been selected by the DRCD as part of the National Broadband Plan to receive highspeed connectivity. The locations of the BCPs have been selected by local authorities and include public areas such as community halls, libraries, sports facilities, enterprise hubs, tourist locations and other public spaces.
12.3 Future Research
The research undertaken here was the exploratory cycle of a larger DBR project. While the results of this exploratory cycle to date have produced both practical educational interventions and theory generation, further explanatory and confirmatory investigation is required. A further three concurrent four-part programmes were scheduled to begin in April 2020 but were unfortunately cancelled due to Irish Government COVID19 restrictions. This had an impact on the sample size and range of contexts. In order to begin to address this issue, those three programmes will go ahead, facilitated by facilitators trained by the researcher. It is anticipated that the total sample will include c.80 total participants including c.27 parents. The purpose of this is confirmatory and findings will be used to further triangulate, complement and extend the research described here.

The planned expansion of the OurKidsCode project described in Section 12.2.4, gives the opportunity to then conduct a second cycle of the study with larger samples over many different contexts. This will provide opportunities to take a more explanatory approach or an in-depth analysis of the reasons behind any changes in order to establish how and why, as well as if, the Design Principles are having an impact. It will also allow for the investigation of the medium and long-term impacts of participation.

Following this, and only after further confirmation that it is possible to design an intervention resulting in the desired outcomes, the focus of the research will shift to inputs or conditions necessary for the interventions to function in the intended contexts. Fishman et al. have complained that most DBR does not explicitly address systemic issues of usability, scalability and sustainability and that “this limitation must be overcome if research is to create usable knowledge that addresses the challenges … when implemented in real-world… contexts”(2004, p. 43). The researcher acknowledges that research into any interventions consequent to this study needs to be cognisant of the complexities involved in delivery. This point is especially pertinent as the scaling of the OurKidsCode project needs to be accompanied by a broadening of the research focus and be guided by a rigorous research process in order to continue the commitment to the establishment and sharing of evidence-based best practice. Some of these broader issues are discussed in the following section.

12.4 Related Research
The decision to limit the scope of the predictor factors identified to that of computing attitudes and behaviours for the purpose of the research, should not lead to the assumption
that the findings are not set within the broader ecology of educational policy and social values. That is, the findings should be set within the context of recommendations for action from other domains important to understanding and supporting PI. As previously noted, there are many other relevant factors and variables involved in the successful implementation of PI initiatives (Desforges & Abouchaar, 2003).

The demographic make-up of participants impacts issues around uptake, implementation, and sustainability and needs to be investigated. For example, the issue of gender (in light of the over-representation of female respondents in the samples) is of particular interest considering the under-representation of women in CS. Gender (of both the parent and child) is a particularly complex issue when it comes to PI having an impact on its quantity, nature and outcomes (Clarke-Midura et al., 2019; Vekiri & Chronaki, 2008; Wang et al., 2015).

Socio-economic factors also need to be accounted for. Particularly in light of the study’s finding that availability or access to hardware and software can create further barriers to involvement. Barron et al. recommend that schools, libraries, community organizations and other public institutions provide access in order to support “more equitable robust learning ecologies” (2019, p. 351). Accordingly, the OurKidsCode project is leveraging the BCP network as previously described and will investigate the impact of increased access on the participation of different socio-economic groups.

Changing definitions of ‘family’ also give rise to interesting questions. Consideration of this was prompted by a discussion that took place in one of the facilitator focus groups about the definition of ‘family’, with general agreement that grandparents were a natural audience for these interventions, particularly in the Irish context where they provide considerable childcare support for working parents. However, another audience that had not been previously considered was that of foster parents, a group which one of the participants was involved in supporting: “Just thinking of the broader community, 5,000 children in Ireland live with foster parents and I would hope that this could be an opportunity for them too, maybe it could be used as an icebreaker for the children to the new foster parents?” There is increasing awareness of these broader definitions of ‘family’ and this needs to be carefully considered by anyone running interventions for families. These considerations also need to be informed by any child safe-guarding guidelines and laws that are applicable.
12.5 Conclusion
Barab & Squire argue that, with respect to DBR, consequentiality is an essential criterion for determining the significance of any study: “Our goal... is to directly impact practice while advancing theory that will be of use to others” (2004, p. 8). In assessing the impact of this research, it is therefore necessary to look at both local impact and advances in theory. Indeed, DBR contends that the value of this theory can not only be more fully understood through its consequences on the local context, but the Design Experiments should be treated as contexts through which theory may be advanced (DiSessa & Cobb, 2004).

The research described in this dissertation began by establishing a theoretical framework that could be used to understand the factors contributing to PI in CS Education. This drew on prior analogous research, consultation with domain experts, and the analysis of responses to the validated survey instrument. The findings provided us with factors that interventions to support PI in CS Education should target. A further literature review was conducted to identify pedagogy that may be appropriate for targeting those factors and a set of Design Principles was thus produced.

The exploratory Design Experiments, grounded in the Design Principles, provided an opportunity to observe the local impact of operationalising this theory. Impacts included pre-post- confidence gains, parent attitudinal changes, positive attitudes of facilitators, and the further dissemination of workshops. The experiments provided a richer understanding of factors predicting PI in CS Education, and further extended the knowledge of how best to target those factors.

The interrogations of the two research questions complemented each other. While the predominantly quantitative method of the survey used to explore RQ1 revealed broad patterns uncovering theoretical relationships, the Design Experiments, particularly through the collection of qualitative data, facilitated local clarification through observation, description and interpretation of the Design Principles in action, and the role of the families, facilitators and activities.

From a theoretical perspective, the findings have the potential to guide future empirical research into the design of PI strategies by providing a greater understanding of the factors that affect PI in CS Education. The research also provides a validated instrument to support both the design and evaluation of any such strategies. In addition, it offers an evidence-based domain-specific instructional theory to support the design of relevant interventions in the form of the Design Principles.
In line with the pragmatic DBR approach adopted, alongside this theory construction and exploration runs a commitment to solving real-world problems (T. Reeves et al., 2005). While acknowledging the limitations of the research, the exploration of the impact of the resulting workshops through the Design Experiments shows promising indications of a positive impact on PI attitudes and behaviour.

Funding has been secured to roll the workshops out across Ireland and evaluation of their impact along with research into usability, scalability and sustainability is continuing.
References


https://www.ncca.ie/media/2605/computer_science_report_sc.pdf


References


Appendices

Appendix A  Ethics Committee Approvals

Appendix A Figure 1. TCD Research Ethics WebApp approvals record
Appendix B  Domain Expert Focus Group Exploratory Framework

The following table contains open exploratory questions designed for administration, as prompts, to a domain expert/educator focus group. These questions are adapted from Goh (2015) and based in theory exploring inhibitors to parents using technology with primary age children.

<table>
<thead>
<tr>
<th>Domain Expert / Educator Focus Group Questions</th>
<th>Related Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Parental attitude towards teaching computing</td>
<td>What do you perceive as the main factors inhibiting parents from teaching computing to their children?</td>
</tr>
<tr>
<td>2. Inhibitors to child learning computing from parents</td>
<td>What do you perceive as the main factors inhibiting children from learning computing from their parents?</td>
</tr>
<tr>
<td>3. Parental gender inhibitors and computing</td>
<td>To what extent do you perceive parental gender as an inhibitor to their children learning computing?</td>
</tr>
<tr>
<td>4. Parental as computing role models</td>
<td>How important is it that parents are computing role models?</td>
</tr>
<tr>
<td>5. Age inhibitors and computing</td>
<td>To what extent do you perceive the child's age as an inhibitor to learning computing?</td>
</tr>
<tr>
<td>6. Socio-Demographic Inhibitors</td>
<td>What do you perceive as the main socio-demographic inhibitors to parents teaching computing?</td>
</tr>
<tr>
<td>7. Technical Infrastructure</td>
<td>How important is it that parents have access to computing and internet resources at home and why?</td>
</tr>
<tr>
<td>8. Computing together</td>
<td>How important is it that parents learn computing together and what are the perceived benefits?</td>
</tr>
<tr>
<td>9. Parental Rules and Online Computing Content</td>
<td>How important is it that we give parents guidelines and rules for using with their children when accessing computing resources and interacting with computing communities in online environments?</td>
</tr>
<tr>
<td>10. Parental access to offline resources</td>
<td>How important is it that we give parents access to offline resources and what content, resources would you advise?</td>
</tr>
<tr>
<td>11. Proprietary content</td>
<td>How important is it that we advise parents on their digital rights in terms of publishing and controlling as well as copyrighting materials?</td>
</tr>
</tbody>
</table>
### Appendix C  PICS Survey Instrument

#### Availability

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>How many of these devices do you have in your home?</td>
<td>Matrix of dropdown menus</td>
<td>Devices:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Number of each: 1-10</td>
<td>- Smartphone/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- iPod Touch/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- iPad or Tablet PC/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Games Console/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Laptop Computer/</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Desktop Computer</td>
</tr>
<tr>
<td>11</td>
<td>How would you rate the quality of your internet connection?</td>
<td>5-part Likert-type Item (poor-excellent)</td>
<td>- Poor</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Below Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Above Average</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Excellent</td>
</tr>
</tbody>
</table>

#### Usage: Creation

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>What do you use these devices for in your home?</td>
<td>Checkboxes</td>
<td>- Desktop publishing and design</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Creating media (videos, music, animations...)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Making websites</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Programming</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Robotics or electronics</td>
</tr>
</tbody>
</table>

#### Usage: Consumption

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>What do you use these devices for in your home?</td>
<td>Checkboxes</td>
<td>- Browsing the Internet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Watching videos</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Listening to Music</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Playing Games</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Online shopping</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Video chat and voice calls</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Sending and receiving email</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Interacting with social media</td>
</tr>
</tbody>
</table>
## Confidence

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
</table>
| 16                   | When the computer doesn’t do what I expect I immediately ask someone for help. | 5-part Likert Scale | - Strongly disagree  
- Disagree  
- Neither agree nor disagree  
- Agree  
- Strongly agree |
| 17                   | I get other people to set up the equipment in my house, e.g. internet, home entertainment, PC/laptop/tablet, printer... |             |                                      |
| 18                   | I do tasks on the computer by writing down or memorising the steps I have to follow - if something goes wrong, I’m a bit lost |             |                                      |
| 19                   | I feel comfortable about my ability to work with computers.              |             |                                      |
| 20                   | Learning new things on computers is confusing for me.                    |             |                                      |
| 21                   | I get anxious when using new things on computers because I don’t know what to do if something goes wrong. |             |                                      |
| 22                   | I am confident with my ability to troubleshoot when problems arise while using computers. |             |                                      |
| 23                   | I am confident in trying to learn new things on computers on my own.     |             |                                      |
| 25                   | I get anxious when using computers with my child/children.              |             |                                      |
### Attitude to PI in CS Education

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
</table>
| 24                   | I get excited when I am able to show my child/children a way to make things with computers. | 5-part Likert Scale  | - Strongly disagree  
- Disagree  
- Neither agree nor disagree  
- Agree  
- Strongly agree |
| 26                   | I regularly plan tasks and activities in which my child/children and I use computers together. |                      |                                                                            |
| 27                   | I want my child to have fun when learning about computers.               |                      |                                                                            |
| 28                   | I want to help my child understand what computer programming does.       |                      |                                                                            |
| 29                   | I want to spend time with my child when they are learning about computers. |                      |                                                                            |
| 30                   | Learning new things about computers that I can use with my family is important to me. |                      |                                                                            |

### Experience

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
</table>
| 32                   | Which of the following best describes your level of programming?         | Multiple Choice      | - I have never tried to program at all  
- I have tried to write a program but didn’t feel I succeeded  
- I have successfully written programs for myself  
- I have successfully written programs requested/paid for by others  
- Other (please specify) |

### Motivation for PI in CS Education

<table>
<thead>
<tr>
<th>Original Item Number</th>
<th>Question</th>
<th>Item Format</th>
<th>Item Values</th>
</tr>
</thead>
</table>
| 34                   | It is important to teach my child/children about the role computers play in society. | 5-part Likert Scale  | - Strongly disagree  
- Disagree  
- Neither agree nor disagree  
- Agree  
- Strongly agree |
| 35                   | I would like to be able to help my child decide if they would like to be a Computer Scientist, or work in technology in the future. |                      |                                                                            |
| 36                   | All children should have an opportunity to learn about computing in primary school. |                      |                                                                            |
Appendices

Appendix D  The Child Learner-Requirements Survey Instrument

This survey should be completed with the help of your parent/guardian.

We need your help to understand how you use computers at home so that we can build workshops to help you and your family learn more about using computer technologies. We’ve asked your parents to help you answer some questions about the kinds of things that you already do with computers and how you feel about them.

WHAT IS THE PURPOSE AND WHAT TYPE OF QUESTIONS WILL I BE ASKED?

Please consider this survey with a parent/guardian.

It will take about 10-15 minutes to complete. There are questions that have checkboxes and others where you write an answer.

Please inform your answers in your answers. If you do not have them, then the answers provided must be valid, as false answers will not be accepted.

Questions are optional. This means that you can choose not to answer questions or skip them if you like.

You can change your answers at any time and you can stop at any time by clicking “Stop” or by closing the browser.

methods: 

The parent/Guardian’s role is to ensure that the survey is completed accurately, and that the information provided is accurate.

Before you submit the survey, you will be asked to provide your name, name of your school, and name of your class.

This information is used to identify your responses, and to provide feedback about the survey.

respondents: 

The survey is anonymous, and all responses will be treated as confidential.

The survey is conducted online, and your responses will be stored in an encrypted database.

The survey is intended for educational purposes, and will be used for research and teaching.

We are a group of researchers who are working on survey research in the field of computer science.

The project receives funding from a variety of sources, including the National Science Foundation.

I have been provided with an information and consent sheet detailing how my child’s data will be processed and how I can contact the research team. I have read, or had read to me, an information page providing information about this research and this consent form.

1. Do you consent to your child’s participation? Yes No

2. What are you? Male Female


4. What is your job? Professional, Blue Collar, White Collar, Unknown

5. What is your age? 20-29 30-39 40-49 50-59

6. Which of the following do you use at home? Smartphone Tablet Laptop Desktop computer

7. Please identify your household member.

I have read, or had read to me, information telling me what will happen to my answers and how (my parent/guardian) can contact the research team.

You can contact us at our contact@ourkidscode.org or our School of Computer Science & Statistics, Trinity College, Dublin 2.

Please click “Next” to continue where your parent can give consent.
Appendices

QurKidsCode Child Survey

What do you use computers for?

- Playing games
- Watching videos
- Using apps (e.g., Facebook, Instagram)
- Writing stories
- Doing homework
- Creating media (music, videos, animations)
- Working on school projects

QurKidsCode Child Survey

How much time do you spend using computers?

- Always
- Most of the time
- Sometimes
- Rarely
- Never

QurKidsCode Child Survey

Screen Time

This is about how much time you spend using computers.

QurKidsCode Child Survey

These are the skills you think you need about Computers.

- Coding
- Problem Solving
- Creativity
- Critical Thinking

QurKidsCode Child Survey

Comparing with your parents/guides:

Please select one option in each scale.

- My parents/guides help me search for information on the Internet
- My parents/guides help me with computer games
- My parents/guides help me with computer programming
### OurKidsCode Workshops

We are planning to run some workshops where you and your family can learn to use computers by making some fun and interesting things together. Do these sound like something you’d like to take part in?

- [ ] Yes
- [ ] No
- [ ] Maybe

### OurKidsCode Child Survey

**Survey Complete - Thank you!**

Thank you so much for completing this survey.

Just a reminder that the project is funded by Science Foundation Ireland and administered by the National Parents Council in partnership with the School of Computer Science and Statistics, Trinity College Dublin, the team are Professor Iris Strachan, Professor Dennis Grigg, Katrina Fisher and Di Roche (National Parents Council Primary).

Please do not hesitate to contact us with any further questions at info@ourkidscode.com or the School of Computer Science and Statistics, Trinity College Dublin, Dublin 2.

The survey for parents/guardians is available at

https://www.surveymonkey.com/r/ourKidscode_parent

You may exit the survey without submitting by closing your browser window.

---

<table>
<thead>
<tr>
<th>Question</th>
<th>1 (Never)</th>
<th>2 (Rarely)</th>
<th>3 (Sometimes)</th>
<th>4 (Often)</th>
<th>5 (Always)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25. My parents/guardians decide on the activities that I can and cannot do on the computer.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>26. I don’t like my parents/guardians seeing what I’m making or doing on the computer</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>27. I decide by myself what to do on the computer</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>28. I ask my parents/guardians for advice when I have technical problems with the computer</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>29. My parents/guardians decide when I can use the computer and the Internet</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>30. I can decide when I am able to show my parents/guardians something I made on the computer</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>31. I want to learn about computers on my own with no help.</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>32. I enjoy it when my parents/guardians spend time with me on the computer</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>
Appendix E

The OurKidsCode Cards

The supporting cards are divided into five groups (coded by both colour and title for ease of identification during the workshop). Each workshop makes use of a specific set of cards which the facilitator organises ahead of the workshop proper.

**Reference** cards (pink) help explain the project ideas and principles, and are used by the facilitator ahead of time to ensure they are familiar with the project structure and goals.

**Setup** cards (purple) help facilitators organise the workshop, and include information about the Icebreaker which begin the workshop activities.

**Workshop** cards (yellow) guide the workshop participants; each workshop has step-by-step instructions on A5 cards, one set of which is given to each family.

**Example** cards (green) contain explanations of specific topics and can be referenced by families during the workshops to aid understanding when family members wish to investigate a topic more than the workshop strictly requires; The Workshop cards will reference these occasionally.

**Technical** cards (blue) help guide the use of technology during the workshop, and are referenced by the Workshop cards at suitable times (for example, card T2 gives an illustrated guide to visiting and signing into the Scratch web site). This allows the Workshop cards to focus on the specific workshop activity.

---

Appendix E Figure 1. Example Card to Explain Workshop Roles

Appendix E Figure 2. Setup Card with Information about the Icebreaker
Appendix F  Design Experiments Data Collection Instruments

Parent Pre-Questionnaire

OurKidsCode Workshop Pre-Survey

About You
Please provide the following information about yourself.

1. Name: [Surname, First Name]

2. Date of Birth:
   Example: December 15, 2012

3. Gender
   Male
   Female
   Other

Previous Experiences
4. Have you previously done any computing activities at home?
   Yes
   No

5. If yes, where did you do these activities?
   Schools
   Other
   Weekends / organised activities
   Other
   None

How you feel about Computing
Please circle the item that best describes your feelings with the following statements about your usual computing activities, today and in the past.

13. Computers frighten me.
    [Very much]

14. I consider myself a more skilled computer user than most people.
    [Very much]

15. I am very aware of my ability to use computers.
    [Very much]

Family Computing
Please circle the item that best describes your feelings with the following statements about your family’s computing activities.

16. I used to help my family with computing activities at home.
    [Very much]

17. I feel able to organise computing activities at my home.
    [Very much]

Survey Complete - Thank you!
Thank you so much for completing this survey.

Appendices 212
# Patent Post-Questionnaire

## About You

<table>
<thead>
<tr>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Date of Birth</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 15, 2013</td>
</tr>
</tbody>
</table>

## How you feel about Computing

Please rate your level of agreement with the following statements about your use of computers on a scale from 1 (strongly disagree) to 5 (strongly agree).

1. I am very confident in my ability to use computers.
   - 1: Strongly disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly agree

2. I often have difficulties when trying to learn how to do new things on a computer.
   - 1: Strongly disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly agree

3. I am very confident in my ability to use computers.
   - 1: Strongly disagree
   - 2: Disagree
   - 3: Neither agree nor disagree
   - 4: Agree
   - 5: Strongly agree

## Further Comments

Please feel free to leave any further comments or feedback on today’s workshop:

---

### Survey Complete - Thank you

Thank you for completing the survey.

---

213
Fieldnotes and Observation Protocol

The workshop is observed by the researcher who will write notes and count behaviours using this one page template.

The workshop is divided into steps which are taken in sequence to engage in a creative collaborative activity. The final step in the workshop is a facilitated plenary reflection (focus group) which although could be seen as a research data collection moment, is also proposed as the final workshop step in order to foster recognition of learning.

The template is two columns and n rows - one row for each main step in the workshop. On the left is a space for free writing - Field notes. On the right are key terms to guide and count observed behaviours.

There is a space at the bottom of the template for overall observations by the researcher.

---

**OurKidsCode Pilot Workshop Field notes & Observation template**

**Step 1**

<table>
<thead>
<tr>
<th>Fieldnotes</th>
<th>Observation Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smiles/beams with others</td>
<td>Cartoon smiles at others</td>
</tr>
<tr>
<td>PRaises others</td>
<td>Historical others</td>
</tr>
<tr>
<td>Uses language of creating</td>
<td>Struggles with jargon</td>
</tr>
<tr>
<td>Identifies as coder/maker</td>
<td>This is not me</td>
</tr>
<tr>
<td>Asks questions</td>
<td>Seeks answers</td>
</tr>
<tr>
<td>Expresses excitement</td>
<td>Boost</td>
</tr>
<tr>
<td>Debates choices</td>
<td>Seeks direction</td>
</tr>
<tr>
<td>Celebrates outcomes</td>
<td>Uninterpreted outcomes</td>
</tr>
<tr>
<td>Listens to others</td>
<td>ignores others</td>
</tr>
<tr>
<td>Taking notes</td>
<td>Does everything</td>
</tr>
</tbody>
</table>

**Step 2**

<table>
<thead>
<tr>
<th>Fieldnotes</th>
<th>Observation Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smiles/beams with others</td>
<td>Cartoon smiles at others</td>
</tr>
<tr>
<td>PRaises others</td>
<td>Historical others</td>
</tr>
<tr>
<td>Uses language of creating</td>
<td>Struggles with jargon</td>
</tr>
<tr>
<td>Identifies as coder/maker</td>
<td>This is not me</td>
</tr>
<tr>
<td>Asks questions</td>
<td>Seeks answers</td>
</tr>
<tr>
<td>Expresses excitement</td>
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</tr>
<tr>
<td>Debates choices</td>
<td>Seeks direction</td>
</tr>
<tr>
<td>Celebrates outcomes</td>
<td>Uninterpreted outcomes</td>
</tr>
<tr>
<td>Listens to others</td>
<td>ignores others</td>
</tr>
<tr>
<td>Taking notes</td>
<td>Does everything</td>
</tr>
</tbody>
</table>

**Step 3**

<table>
<thead>
<tr>
<th>Fieldnotes</th>
<th>Observation Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smiles/beams with others</td>
<td>Cartoon smiles at others</td>
</tr>
<tr>
<td>PRaises others</td>
<td>Historical others</td>
</tr>
<tr>
<td>Uses language of creating</td>
<td>Struggles with jargon</td>
</tr>
<tr>
<td>Identifies as coder/maker</td>
<td>This is not me</td>
</tr>
<tr>
<td>Asks questions</td>
<td>Seeks answers</td>
</tr>
<tr>
<td>Expresses excitement</td>
<td>Boost</td>
</tr>
<tr>
<td>Debates choices</td>
<td>Seeks direction</td>
</tr>
<tr>
<td>Celebrates outcomes</td>
<td>Uninterpreted outcomes</td>
</tr>
<tr>
<td>Listens to others</td>
<td>ignores others</td>
</tr>
<tr>
<td>Taking notes</td>
<td>Does everything</td>
</tr>
</tbody>
</table>

**Step 4**

<table>
<thead>
<tr>
<th>Fieldnotes</th>
<th>Observation Protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smiles/beams with others</td>
<td>Cartoon smiles at others</td>
</tr>
<tr>
<td>PRaises others</td>
<td>Historical others</td>
</tr>
<tr>
<td>Uses language of creating</td>
<td>Struggles with jargon</td>
</tr>
<tr>
<td>Identifies as coder/maker</td>
<td>This is not me</td>
</tr>
<tr>
<td>Asks questions</td>
<td>Seeks answers</td>
</tr>
<tr>
<td>Expresses excitement</td>
<td>Boost</td>
</tr>
<tr>
<td>Debates choices</td>
<td>Seeks direction</td>
</tr>
<tr>
<td>Celebrates outcomes</td>
<td>Uninterpreted outcomes</td>
</tr>
<tr>
<td>Listens to others</td>
<td>ignores others</td>
</tr>
<tr>
<td>Taking notes</td>
<td>Does everything</td>
</tr>
</tbody>
</table>

**Reflection**

**Overall**
**Parent Follow-on Questionnaire**

**ABOUT YOU**

2. What is your gender?
   - Male
   - Female
   - Other

3. What is your age range?
   - 18-25
   - 26-35
   - 36-45
   - 46 and over

4. Please select which school you took part in the OurKidsCode Workshop
   - DT Educate Together, June 2018
   - Raindfort National School, May, June 2018
   - DT Educate Together, October 2018

5. What do you recall learning in the workshop?

6. When you left the workshop, how eager were you to engage in further computing activities with your family?

7. How well prepared were you to do any further computing activities?

8. Did you go on to do further computing activities with your family or with other families?
   - Yes
   - No

9. If 'Yes', what did you do?

10. If you are not doing some of the things that you were encouraged to do, why not?
    - It wasn’t practical for my situation
    - I haven’t found the time
    - I tried it and it didn’t work
    - My family weren’t interested
    - Other (please specify)

11. Are you planning any family computing activities in the future?
    - Yes
    - No

12. If ‘Yes’, what are you planning?

13. What suggestions do you have for making the workshops more helpful?
Parent Focus Group Protocol

The following table contains open exploratory questions that will be used as prompts, with parents encouraged to share their experiences which will feed into the evaluation of the workshop model.

<table>
<thead>
<tr>
<th>Question 1</th>
<th>To what extent were the workshops well organised and easy to understand?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question 2</td>
<td>To what extent did you find the facilitation helpful?</td>
</tr>
<tr>
<td>Question 3</td>
<td>To what extent were the workshops useful?</td>
</tr>
<tr>
<td>Question 4</td>
<td>To what extent do you intend to use the content from today’s workshop at home?</td>
</tr>
<tr>
<td>Question 5</td>
<td>What workshop areas would you like to spend more or less time on?</td>
</tr>
<tr>
<td>Question 6</td>
<td>What key learning/learnings did you or your family take away from today’s workshop?</td>
</tr>
<tr>
<td>Question 7</td>
<td>Having completed today’s workshop what might you now do differently?</td>
</tr>
<tr>
<td>Question 8</td>
<td>Would you like to attend another workshop and if yes why?</td>
</tr>
</tbody>
</table>
Facilitator Pre-Questionnaire

1. **ABOUT YOU**
   - What is your gender?
     - Male
     - Female
     - Other
   - What is your age range?
     - 25-30
     - 31-35
     - 36-40
     - 41+

2. **HOW DO YOU USE COMPUTERS IN YOUR WORK?**
   - Please share your professional experience to provide feedback which can help develop a training programme that meets your professional development needs.

3. **WHAT WORKSHOPS DO YOU CURRENTLY FACILITATE?**

4. **WHICH OF THE FOLLOWING BEST DESCRIBES YOUR LEVEL OF PROGRAMMING?**
   - I have never tried to program at all
   - I have tried to write a program but didn’t feel I succeeded
   - I have successfully written programs for myself
   - I have successfully written programs specifically for my workplace

5. **HOW DO YOU FEEL ABOUT COMPUTING?**

6. **WHY DO YOU WANT TO DO THE JAMITCODING WORKSHOPS?**
   - Why do you want to do the JAMITCODING training workshops?
### Appendix A

1. I get anxious when using new things on computers because I don’t know what to do if something goes wrong.
   - [ ] Slightly disagree
   - [ ] Somewhat disagree
   - [ ] Neither agree nor disagree
   - [ ] Somewhat agree
   - [ ] Slightly agree

2. I am confident with my ability to troubleshoot when problems arise while using computers.
   - [ ] Slightly disagree
   - [ ] Somewhat disagree
   - [ ] Neither agree nor disagree
   - [ ] Somewhat agree
   - [ ] Slightly agree

3. I am confident in trying to learn new things on computers on my own.
   - [ ] Slightly disagree
   - [ ] Somewhat disagree
   - [ ] Neither agree nor disagree
   - [ ] Somewhat agree
   - [ ] Slightly agree

---

### Appendix B

**Survey Title:**

Why do you want to do the "QumulCode: Thinking Workshop?"

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Facilitator Post-Questionnaire

1. WHAT WAS YOUR OVERALL EXPERIENCE OF THE TRAINING?
   - Excellent
   - Good
   - Average
   - Below Average
   - Poor

2. WHAT WAS THE MOST USEFUL INFORMATION YOU LEARNED?
   (Please provide details)

3. WHAT WAS THE MOST PRACTICAL INFORMATION YOU LEARNED?
   (Please provide details)

4. WHAT WAS THE MOST THEORETICAL INFORMATION YOU LEARNED?
   (Please provide details)

5. WHAT WAS THE MOST CHALLENGING ASPECT OF THE TRAINING?
   (Please provide details)

6. WHAT WAS THE MOST EASY TO UNDERSTAND ASPECT OF THE TRAINING?
   (Please provide details)

7. WHAT WAS THE MOST INTERESTING ASPECT OF THE TRAINING?
   (Please provide details)

8. WHAT WAS THE MOST BORING ASPECT OF THE TRAINING?
   (Please provide details)

9. WHAT WAS THE MOST PAINFUL ASPECT OF THE TRAINING?
   (Please provide details)

10. WHAT WAS THE MOST ENJOYABLE ASPECT OF THE TRAINING?
    (Please provide details)

11. WHAT WAS THE MOST VALUABLE ASPECT OF THE TRAINING?
    (Please provide details)

12. WHAT WAS THE MOST WASTED TIME?
    (Please provide details)

13. WHAT WAS THE MOST VALUABLE INFORMATION TO YOU?
    (Please provide details)

14. WHAT WAS THE MOST USEFUL INFORMATION TO YOU?
    (Please provide details)

15. WHAT WAS THE MOST PRACTICAL INFORMATION TO YOU?
    (Please provide details)

16. WHAT WAS THE MOST THEORETICAL INFORMATION TO YOU?
    (Please provide details)

17. WHAT WAS THE MOST CHALLENGING ASPECT TO YOU?
    (Please provide details)

18. WHAT WAS THE MOST EASY TO UNDERSTAND ASPECT TO YOU?
    (Please provide details)

19. WHAT WAS THE MOST INTERESTING ASPECT TO YOU?
    (Please provide details)

20. WHAT WAS THE MOST BORING ASPECT TO YOU?
    (Please provide details)

21. WHAT WAS THE MOST PAINFUL ASPECT TO YOU?
    (Please provide details)

22. WHAT WAS THE MOST ENJOYABLE ASPECT TO YOU?
    (Please provide details)

23. WHAT WAS THE MOST VALUABLE ASPECT TO YOU?
    (Please provide details)

24. WHAT WAS THE MOST WASTED TIME?
    (Please provide details)

25. WHAT WAS THE MOST VALUABLE INFORMATION FOR YOU?
    (Please provide details)

26. WHAT WAS THE MOST USEFUL INFORMATION FOR YOU?
    (Please provide details)

27. WHAT WAS THE MOST PRACTICAL INFORMATION FOR YOU?
    (Please provide details)

28. WHAT WAS THE MOST THEORETICAL INFORMATION FOR YOU?
    (Please provide details)

29. WHAT WAS THE MOST CHALLENGING ASPECT FOR YOU?
    (Please provide details)

30. WHAT WAS THE MOST EASY TO UNDERSTAND ASPECT FOR YOU?
    (Please provide details)

31. WHAT WAS THE MOST INTERESTING ASPECT FOR YOU?
    (Please provide details)

32. WHAT WAS THE MOST BORING ASPECT FOR YOU?
    (Please provide details)

33. WHAT WAS THE MOST PAINFUL ASPECT FOR YOU?
    (Please provide details)

34. WHAT WAS THE MOST ENJOYABLE ASPECT FOR YOU?
    (Please provide details)

35. WHAT WAS THE MOST VALUABLE ASPECT FOR YOU?
    (Please provide details)

36. WHAT WAS THE MOST WASTED TIME?
    (Please provide details)

37. WHAT WAS THE MOST VALUABLE INFORMATION FOR YOU?
    (Please provide details)

38. WHAT WAS THE MOST USEFUL INFORMATION FOR YOU?
    (Please provide details)

39. WHAT WAS THE MOST PRACTICAL INFORMATION FOR YOU?
    (Please provide details)

40. WHAT WAS THE MOST THEORETICAL INFORMATION FOR YOU?
    (Please provide details)

41. WHAT WAS THE MOST CHALLENGING ASPECT FOR YOU?
    (Please provide details)

42. WHAT WAS THE MOST EASY TO UNDERSTAND ASPECT FOR YOU?
    (Please provide details)

43. WHAT WAS THE MOST INTERESTING ASPECT FOR YOU?
    (Please provide details)

44. WHAT WAS THE MOST BORING ASPECT FOR YOU?
    (Please provide details)

45. WHAT WAS THE MOST PAINFUL ASPECT FOR YOU?
    (Please provide details)

46. WHAT WAS THE MOST ENJOYABLE ASPECT FOR YOU?
    (Please provide details)

47. WHAT WAS THE MOST VALUABLE ASPECT FOR YOU?
    (Please provide details)

48. WHAT WAS THE MOST WASTED TIME?
    (Please provide details)

49. WHAT WAS THE MOST VALUABLE INFORMATION FOR YOU?
    (Please provide details)

50. WHAT WAS THE MOST USEFUL INFORMATION FOR YOU?
    (Please provide details)

51. WHAT WAS THE MOST PRACTICAL INFORMATION FOR YOU?
    (Please provide details)

52. WHAT WAS THE MOST THEORETICAL INFORMATION FOR YOU?
    (Please provide details)

53. WHAT WAS THE MOST CHALLENGING ASPECT FOR YOU?
    (Please provide details)

54. WHAT WAS THE MOST EASY TO UNDERSTAND ASPECT FOR YOU?
    (Please provide details)

55. WHAT WAS THE MOST INTERESTING ASPECT FOR YOU?
    (Please provide details)

56. WHAT WAS THE MOST BORING ASPECT FOR YOU?
    (Please provide details)

57. WHAT WAS THE MOST PAINFUL ASPECT FOR YOU?
    (Please provide details)

58. WHAT WAS THE MOST ENJOYABLE ASPECT FOR YOU?
    (Please provide details)

59. WHAT WAS THE MOST VALUABLE ASPECT FOR YOU?
    (Please provide details)

60. WHAT WAS THE MOST WASTED TIME?
    (Please provide details)
Facilitator Follow-on-Questionnaire

1. ABOUT YOU
What is your gender?
- Male
- Female
- Other

2. What is your age range?
- 20-24
- 25-29
- 30-34
- 35-39
- 40 and over

3. TRAINING WORKSHOP FOLLOW-UP
What do you recall learning in the training workshop?

4. When you finished the training, how eager were you to organise a computing workshop?
- Very eager
- Quite eager
- Not so eager
- Not at all
- Other

5. When you finished the training, how well prepared were you to organise a computing workshop?
- Very
- Slightly
- Not at all
- Other

6. - Skip to
If you did not organise a computing workshop, why not?
- It wasn’t practical for my situation
- I wasn’t familiar with the topic
- I wanted it and it didn’t work
- My community wasn’t interested
- Other (please specify)

7. Are you planning any computing workshop in the future?
- Yes
- No
- If yes, what are you planning?

8. FUTURE TRAINING WORKSHOPS
What suggestions do you have for making the workshops more helpful?
**Facilitator Focus Group Protocol**

The following table contains open exploratory questions that will be used as prompts, with parents encouraged to share their experiences which will feed into the evaluation of the workshop model.

<table>
<thead>
<tr>
<th>Question 1</th>
<th>To what extent were the workshop topics well organised and easy to understand?</th>
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<tbody>
<tr>
<td>Question 2</td>
<td>To what extent did you find the facilitation helpful?</td>
</tr>
<tr>
<td>Question 3</td>
<td>To what extent was completing the workshop useful? In what context?</td>
</tr>
<tr>
<td>Question 4</td>
<td>Do you intend to use the content from today’s workshop?</td>
</tr>
<tr>
<td>Question 5</td>
<td>What workshop areas would you like to spend more or less time on?</td>
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<td>Question 6</td>
<td>What key learning/learnings did you take away from today’s workshop?</td>
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<td>Question 7</td>
<td>Having completed today’s workshop what might you now do differently?</td>
</tr>
<tr>
<td>Question 8</td>
<td>Would you like to attend another workshop and if yes why?</td>
</tr>
<tr>
<td>After some information about future plans (4-part programme) being shared.</td>
<td></td>
</tr>
<tr>
<td>Question 9</td>
<td>Do you think that families would attend?</td>
</tr>
<tr>
<td>Question 10</td>
<td>What context/locations would work?</td>
</tr>
<tr>
<td>Question 11</td>
<td>How would you keep the participants engaged?</td>
</tr>
<tr>
<td>Question 12</td>
<td>How could we encourage them to keep going after it ends?</td>
</tr>
<tr>
<td>Question 13</td>
<td>Would you be interested in becoming a facilitator?</td>
</tr>
</tbody>
</table>
Appendix G  Sample of Coded Qualitative data from Nvivo