CODEPLUS: EVALUATING THE SHORT AND LONG-TERM IMPACT OF A COMPUTING OUTREACH PROGRAMME FOR GIRLS

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

The University of Dublin

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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.

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Grace Lawlor

Ethics Declaration

Project Title: CodePlus- An investigation into the effects of a social constructivist all-female CS outreach programme on girls' interest in studying computer science at third level.

Name of Lead Researcher (student in case of project work): Grace Lawlor

Name of Supervisor: Brendan Tangney

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Course Name and Code (if applicable): n/a

Estimated start date of survey/research: 1/Oct/2017

I confirm that I will (where relevant):

- Familiarize myself with the Data Protection Act and the College Good Research Practice guidelines
www.tcd.ie/info_compliance/dp/legislation.php;
- Tell participants that any recordings, e.g. audio/video/photographs, will not be identifiable unless prior written permission has been given. I will obtain permission for specific reuse (in papers, talks, etc.)
- Provide participants with an information sheet (or web-page for web-based experiments) that describes the main procedures (a copy of the information sheet must be included with this application)
- Obtain informed consent for participation (a copy of the informed consent form must be included with this application)
- Should the research be observational, ask participants for their consent to be observed
- Tell participants that their participation is voluntary
- Tell participants that they may withdraw at any time and for any reason without penalty
- Give participants the option of omitting questions they do not wish to answer if a questionnaire is used
- Tell participants that their data will be treated with full confidentiality and that, if published, it will not be identified as theirs
- On request, debrief participants at the end of their participation (i.e. give them a brief explanation of the study)
- Verify that participants are 18 years or older and competent to supply consent.
- If the study involves participants viewing video displays then I will verify that they understand that if they or anyone in their family has a history of epilepsy then the participant is proceeding at their own risk
- Declare any potential conflict of interest to participants.
- Inform participants that in the extremely unlikely event that illicit activity is reported to me during the study I will be obliged to report it to appropriate authorities.
- Act in accordance with the information provided (i.e. if I tell participants I will not do something, then I will not do it).

Signed: ... .
Lead Researcher/student in case of project work

Abstract

"Women's equal and meaningful participation in the digital society is seen as both integral to the realization of women's rights in the 21st century, as well as the realization of a just, inclusive and rights based information society and to achieve global objectives around gender equality and women's empowerment by 2030."

(United Nations, 2015)

Addressing the underrepresentation of women in the field of computer science is a long standing challenge (Patitsas, Craig, & Easterbrook, 2014; Spertus, 1991). Key contributing factors to gender imbalance include; lower levels of confidence in girls concerning computing, ingrained negative stereotypes, a lack of visible female role models, and the traditional pedagogical practices of CS undergraduate courses (AAWU, 2000; Beyer, Rynes, Perrault, Hay, & Haller, 2003; Cheryan, Drury, & Vichayapai, 2013; A. Fisher, Margolis, & Miller, 1997).

For several decades, efforts to encourage women to pursue pathways in computer science have been ongoing across a range of educational levels and contexts. In the non-formal learning environment, a significant number of outreach programmes target the adolescent cohort where a sharp drop-off in girls' interest is known to occur. Such initiatives share much by way of approach, including the use of all-female learning environments, providing relevant female role models, and contextualizing computing through engaging programming activities. Despite a considerable number of such initiatives, their impact is relatively under-explored from an academic perspective (Decker, McGill, & Settle, 2016).

This dissertation describes the approach of a non-formal CS outreach programme "CodePlus", designed as an intervention programme to address factors that affect girls' predilection to study computer science, computing and related undergraduate courses[1]. The aims of this research are to provide a structured approach to evaluate the short-term and longitudinal impact of similar CS outreach programmes while also investigating the previously under-examined role of pedagogy in the design and delivery of such programmes.

The justification for this study and its approach are based on the researcher's review of the literature in the area of female underrepresentation in computing and computer science. In accordance, the intervention employed an all-female learning environment with relevant female role models while teaching computer science through a progressive team-based, technology-mediated, learning model – Bridge21 (J. Lawlor, Conneely, Oldham, Marshall, & Tangney, 2018). It was hypothesised that the Bridge21 pedagogical model would contribute positively to the objectives of the intervention and could provide a viable framework for similar programmes into the future.

The study employs a mixed-methods, concurrent nested design strategy to measure the intervention's impact on participants' perceptions of careers, self-efficacy regarding CS and intentions to study in the field of in CS. The research design involved two phases: (1) measuring the short-term impact of the intervention (2) measuring the longitudinal impact of the intervention. Both qualitative and quantitative methods were employed to answer the research questions. Over 1,000 girls participated in the programme from 2015-2020 with 856 participating in the research element.

[1] This term is shortened to CS related courses in the remainder of the dissertation.

The results showed significant short-term positive changes in key attitudinal variables relating to the central phenomenon under investigation;

1. Computer self-efficacy
2. Perceptions of CS
3. Future intentions regarding CS pathways

and affirmed the efficacy of the intervention's design elements. The results of the longitudinal element of the study suggest that the intervention had an enduring influence on a number of participants electing to study a CS or related course against the backdrop of other contributory factors. This is inferred both from data that directly investigates the effect of the intervention and contextual data that highlighted the limited external CS resources and supports available to participants.

This thesis makes both academic and practical contributions to computer science outreach and the broader area of addressing gender imbalance in the field through; A structured meta-analysis of the all-female outreach space, a framework for short-term and longitudinal outreach evaluation and a deeper understanding of how the design elements of CS outreach interventions affect outcomes.

Acknowledgements

The first person I would like to acknowledge is my supervisor Professor Brendan Tangney. Without his ongoing support, kindness, and patience this dissertation would not have been possible. Thank you for talking me down from the ledge on more than one occasion and for believing in me in the times when I needed it most.

Secondly, I would like to thank the students and schools who participated in the CodePlus programme. It was a joy to run the programme over the past 5 years and a privilege to work with such enthusiastic and bright young women. Many thanks to my colleagues and volunteers and our sponsors over the years; The Irish Computer Society, Salesforce, and Science Foundation Ireland who made running the programme possible.

Special thanks to Mr. Philip Byrne who guided me through the early stages of statistical analysis with encouragement and generously gave his time throughout the later stages of the research to advise me. Thank you to all my other CRITE buddies, in particular Ms. Jane O' Hara who has been a true friend through the good and bad days of the process.

To Ann, Bairbre, Ciara, Claire, Emma, Kerrie, Lorna, Sara, and Ruth. My very own all-girls outreach support system since my late teens. I couldn't hope for a more inspirational group of women to love and support me in this journey and I'm proud be your friend.

To the extended clans of Lawlor and O'Brien. Aunties, uncles, and cousins who regularly reached out with kind words, particularly in the last leg to cheer me on to the end.

To my brother John-Michael who made himself available at any time by phone to receive rants, tantrums, and laments with humour and understanding.

To my mother Nora who rightly refuses to tolerate rants, tantrums, or laments but nonetheless gave the love and wisdom only a mother can in such situations. Thanks for all you do for us Mam.

To my partner Ciarán, who was thrown headfirst into the Ph.D journey with me and fully embraced the role. Of all the choices I made during the doctorate, taking you with me was the best.

Finally, to my father John, who laid the foundations for this study through his own doctoral work and was my strength and stay through the darkest hours before the dawn. I dedicate this work to him.

Relevant Publications and Presentations

Journal Article

Lawlor, Grace, Philip Byrne, and Brendan Tangney. "“CodePlus”—Measuring Short-Term Efficacy in a Non-Formal, All-Female CS Outreach Programme." ACM Transactions on Computing Education (TOCE) 20.4 (2020): 1-18.

Podcast Interview

Episode 8: Grace Lawlor, TCDSU Diversity in STEM Podcast

https://anchor.fm/diversity-in-stem/episodes/Episode-8-Grace-Lawlor-e17v380

Research Credits

Research Methods, 2017/18 - School of Education, 10 ECTS

Postgraduate Certificate in Statistics, 2019/20 - School of Computer Science and Statistics, 35 ECTS

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1 Introduction

1.1 Research Overview

1.1.1 Research Context

The persistent and evident failure to attract women to computer science related undergraduate degrees is a well-known challenge that higher education has faced for the past 30 years. In the United States, the proportion of computer and information sciences degrees conferred to women peaked in the mid-1980s at 37%[2] but by the early 1990s men dominated the field and female numbers have been in steady decline since with 2018 figures at 20%. In Ireland, the ratio of male to female students is higher still, with women making up just under 15% of the entrants to computing and IT 3rd level courses (HEA, 2018)[3].

This decline is in sharp contrast to the accelerated growth of the technology sector, where in the USA employment in all computer occupations is projected to increase by 11% from 2019 to 2029[4], offering not only secure and gainful but relatively lucrative employment. Emergent technologies such as cloud computing, AI, data analytics, cyber security, the internet of things, and the overarching ubiquity of computers in our everyday lives drive a growing demand for a skilled IT workforce.

The consequences of gender imbalance in computing reach far further than that of a labour supply issue for the industry. From a societal perspective there is a pragmatic argument for gender diversity amongst those who design our technology. A diverse team is more likely to create products that meet the needs of the wider community. However, when women have no input in the process, technical decisions are based solely on men's experiences, opinions, and judgement, resulting in a male-slanted bias. The "gender-digital divide", as acknowledged by a dedicated United Nations taskforce, is an emerging global ICT society in which women worldwide do not participate equally due to socio-economic, cultural, religious, and socially conforming factors. With a growing trend towards a more connected and digital society, the ramifications of a divide for women could mean lack of engagement and input into shaping the societies and economies the future.

The lack of women's participation in the sector is an anomaly given that many technology companies are at the forefront of progressive workplace policies, praised for valuing work-life balance,[5] flexible working arrangements and well-paid jobs. If there is both a growing demand for graduates with computing skills and increasingly secure and attractive employment conditions on offer why is it that women are so less enticed to the field as their male peers? This question has troubled both the domains of education and industry alike from the dawn of the 90s technological revolution to the present. While a number of studies have examined this phenomenon, thus far there has been no conclusive explanation (Gras-Velazquez, Joyce, & Debry, 2009; Gürer & Camp, 2001; Spertus, 1991; Vitores & Gil-Juárez, 2016).

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[2] https://nces.ed.gov/.
[3] Latest available HEA statistics as of September 2021: https://hea.ie/statistics-archive/
[4] https://www.bls.gov/

Researchers and stakeholders have theorized a number of factors that contribute to an apparent lack of interest or motivation from women concerning computer science. These include sociobiological factors, entrenched gender-roles, negative perceptions of computing culture, lower levels of computing confidence, a lack of female role models and the traditional pedagogical practices of computer science courses (AAWU, 2000; Beyer et al., 2003; Cheryan et al., 2013; A. Fisher et al., 1997). A metaphor commonly used to illustrate the diminishing participation of women in computing along progressive stages of education and employment is that of a “leaky pipeline” (Vitores & Gil-Juárez, 2016). This metaphor characterises the problem as a flow of girls and women into the field that diminishes over time through the chronological stages of education and employment in the field. As is the case for other areas of STEM, the steepest drop-off in female interest in computing careers occurs in early adolescence (Lapan, Adams, Turner, & Hinkelman, 2000; Turner et al., 2008).

Early intervention strategies to foster girls’ interest and motivation in the field are considered a fundamental step in addressing gender imbalance. While only recently is CS gaining traction as a formal school subject, there are other opportunities available to adolescents to explore computer science in the non-formal learning space. The purpose of the majority of these programmes is to encourage more students in general to explore computer science, however, many programmes focus primarily on broadening the participation of girls. Based on the purported factors that affect girls’ interest, these outreach programmes tend to share characteristics in common including all-female learning environments, engaging programming activities, and mentoring from female role models (G. Lawlor, Byrne, & Tangney, 2020).

From an aspirational perspective, the growing trend of girls’ outreach programmes is impressive, nonetheless measuring the impact of such initiatives is notably under-explored (Decker et al., 2016; G. Lawlor et al., 2020). A scarcity of longitudinal studies, small sample sizes, and less structured approaches to research mean that programme effects are difficult to quantify. Besides measuring impact, the role of pedagogy is also under-explored in CS outreach, which would be interesting to explore given the contention that pedagogy is a key factor in attracting and retaining women in undergraduate computer science (AAWU, 2000).

This study concerns the design, administration and analysis of a social-constructivist pedagogical model for an all-female CS outreach programme “CodePlus”, which was ideally situated to engage with a large sample size in a structured research approach including a longitudinal element.

1.1.2 Problem Statements

Literature on gender and computer science would suggest that although there is no single conclusive explanation for female under-representation, there are a number of contributory factors to be considered. These factors include; negative perceptions of computing, lower levels of computing confidence, and a lack of female role models (Beyer et al., 2003; Cheryan et al., 2013; A. Fisher et al., 1997). An acknowledgement of these factors are reflected in many of the shared elements of early intervention programmes targeted at adolescent girls. Despite the efforts of such programmes there are two related problems central to this study which this thesis seeks to address.

1.1.2.1 Problem Statement 1 (PS1)

The impact of all-female computing outreach programmes is under explored from a research perspective. Additionally, research on CS outreach is often limited by small sample sizes and time or budget constraints. There is no clear consensus across such programmes on what to measure in terms of impact, with validated instruments not widely used. As the core objective of these interventions is to foster future interest in the subject, an obvious indicator of impact would be to examine how many participants later choose to study CS related courses. Despite the importance of determining the college pathways of participants through the tracking of participants, such longitudinal studies remain rare (McGill, Decker, & Settle, 2016).

1.1.2.2 Problem Statement 2 (PS2)

In addition to the commonly purported factors contributing to gender imbalance; undergraduate CS courses have been strongly criticised as "bastions of poor pedagogy"(AAWU, 2000), where teachers have a tendency towards an authoritarian, lecture-dependent style (Beyer, 2014). It is suggested that this pedagogical practice is a further deterrent to prospective female students, and there are several notable examples of colleges that overhauled teaching methods in their CS programmes to address this issue (A. Fisher & Margolis, 2002; Klawe, 2013).

It is also interesting on reviewing the literature of all-female outreach programmes to see many shared practices in terms of how learning is organised with teamwork and project-based activities at the forefront. While pedagogical underpinnings may not be made explicit by such programmes, it is not to say that these practices do not play their role. An opportunity to examine this facet of non-formal outreach remains to be explored.

1.1.3 Research Aims

The overarching aim of this research is to demonstrate a structured approach to measuring the impact of computer science outreach programmes for girls. The focus of the research will be on changes in participants' key attitudinal and intention based variables and measuring the longitudinal impact of the programme against the complex and multifaceted factors that affect college pathway decisions.

In consideration of the problem statements, the research aims can be listed as a set of integrated goals:

- To carry out a meta-analysis of relevant research studies and non-research based programmes in the area of all-female computing outreach.
- To develop a framework for assessing both the short-term and longitudinal impact of computer science outreach programmes for girls.
- To gather and analyse data on the previously under-examined role of pedagogy in the design and delivery of computer science outreach programmes.
- To determine other principal aspects of the design and delivery of all-female computer science outreach programmes that may contribute to improving key attitudinal and intentional variables
- To identify areas for further research.

1.1.4 Hypothesis

The CodePlus programme is a practical application of the Bridge21 learning model in the context of a non-formal computer science education programme for adolescent girls. Key elements of the Bridge21 pedagogical model (J. Lawlor, Marshall, & Tangney, 2016) such as teamwork, project-based learning, mentoring and social learning protocols closely align with approaches to computer science teaching ostensibly favoured by women (AAWU, 2000; A. Fisher & Margolis, 2002; Klawe, 2013). Given this alignment it was hypothesised that the Bridge21 pedagogical approach would contribute to improving participants' computer self-efficacy and perceptions of computer science in the short-term.

It was also hypothesised that participation in the intervention would have a positive enduring impact on some participants in terms of influencing a decision to study CS. For those who would not be electing to study CS, the programme at least would afford an informed perspective on the decision. Given the nuanced nature of forming career pathway decisions and the central phenomenon under investigation, the impact of the intervention was to be examined in the context of additional anticipated factors and influences.

1.1.5 Research Questions

In acknowledgement of the aforementioned problem statements and hypothesis, the researcher proposes three primary research questions that guide the study. The first question concerns the short-term impact of the intervention. The second question investigates any enduring effect the intervention may have had on participants. The third question seeks to gain an understanding of how the intervention's approach affected short-term and long-term change. The researcher argues that by addressing these research questions both the problem statements and research aims can be addressed.

Research Question (RQ) 1: What is the short-term effect of the intervention's approach?

Research Question (RQ) 2: What are the longitudinal effects of the intervention's approach?

Research Question (RQ) 3: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term and longitudinal change?

1.2 Positionality and Reflexivity

"An important function of reflexive analysis is to expose the underlying assumptions on which arguments and stances are built. We are socialized into assumptions as we internalize world views, world hypotheses, cultures, cosmologies, thought styles or paradigms"

(Holland, 1999, p. 467)

A researcher's personal characteristics, experiences, beliefs and ideologies have the potential to impact all stages of their research from formulating questions to presenting final analysis of data (Berger, 2015). By acknowledging that all inquiry is laden with values (Mertens, 2003), practicing reflexivity means that the researcher systematically reflects on who he or she is in the inquiry and how this shapes the story (Creswell, 2003).

Reflexivity is of particular importance with regard to qualitative inquiry. Creswell (2003, p. 182) states "Qualitative research is fundamentally interpretive. This means that the researcher makes an interpretation of the data.", and, "It also means that the researcher filters the data through a personal lens that is situated in a specific socio-political and historical moment. One cannot escape the personal interpretation brought to qualitative data analysis.".

The following sub-sections aim to demonstrate how this researcher engaged in a process of reflexivity throughout the study by examining her positionality. This includes details of her background and experience that led to the study, her role within the research, and her personal beliefs concerning the acquisition of knowledge and inquiry. Biases, assumptions and beliefs held by the researcher are considered in how they have may have consciously and subconsciously impacted on the study from design to implementation and analysis.

1.2.1 Researcher's Background

Given the context of this study it may be of interest to note that the author has no professional or academic background in computing. She holds a bachelor's degree in education and worked as a primary school teacher for a number of years before she began a master's degree which is where the seeds of this study were sown.

The two-year part-taught, part-research M.Sc was titled "Technology and Learning" and was hosted by the university's school of computer science and statistics in partnership with the school of education. The course attracted both educational practitioners and industry professionals interested in the synthesis of technology and education. A first year "capstone" project provided an early opportunity for the author to explore computer programming in the context of the primary school curriculum utilising the popular graphical programming language "Scratch". The author was influenced by and invested in the teachings of constructionism (Papert, 1993) and digital fluency (Resnick et al., 2009) which framed a philosophical view of coding as literacy. As a practitioner she experienced first-hand the phenomenon of "hard fun" (Papert, 1993) and how coding could support the development of key skills such as creativity, collaboration, communication and critical thinking.

It was through this project that the author became more deeply involved with the Bridge21 learning programme. She had previously volunteered with the programme during her undergraduate years, chiefly with digital media activities such as movie-making projects. In light of a new appreciation for the role of coding in key skills development, she lent a hand to the computer science orientated branch of the programme. A vacancy on the professional team coincided with the piloting of an all-female CS outreach programme “CodePlus” (Sullivan, Byrne, Bresnihan, O'Sullivan, & Tangney, 2015) and the author left teaching to work full-time for the organisation. By 2016 she had taken over as lead on the CodePlus programme.

The author’s motivations for enrolling as a full-time Ph.D student (2017/18) and subsequent undertaking of the study were two-fold. From an insider-practitioner’s perspective, she could see the positive effects of the programme, driving a desire to quantify and validate its impact. From a more personal perspective, at all stages of her learning the author has both consciously and unconsciously experienced feelings of low self-efficacy regarding computing, maths, and statistics. Reflecting on her own experience in relation to the gatekeeper nature of self-efficacy was helpful in understanding the central phenomenon under investigation.

In this sense, an awareness of biases and empathy with the research participants “adds as much as it detracts from the research validity” (T. Anderson & Shattuck, 2012, p. 18). While every effort was made to remain objective throughout the research process, true objectivity is difficult to achieve in insider research due to the high level of subjective involvement with and closeness to the research setting and participants (Chavez, 2008; M. J. Greene, 2014).

The following section will discuss the author’s beliefs concerning knowledge and inquiry.

1.2.2 Researcher’s Beliefs about Knowledge and Research

At a general level, the purpose of research is to try to resolve or to illuminate a substantive issue. Research by its nature can be predominantly exploratory, explanatory or descriptive. While many studies can be defined by this broad categorisations, they are not mutually exclusive.

The sphere of research is rich in different approaches each with its own traditions, conventions, histories and internal debates. From a pragmatic standpoint, one could argue that a researcher should chose an approach that best fits the objectives of the study, however others would argue that the choice of approach is more of an expression of one’s personal and institutional politics than of a commitment to answering the research questions. The latter standpoint would contend that how one understands and perceives the social universe to work is central to one’s identity as a researcher, influencing all aspects of the study.

Research approaches are located within a paradigm or episteme which in essence refers to an individual’s belief system; how one sees the world, how one thinks it works, how one thinks it should be changed, what counts as valid knowledge and how you think research should be carried out (Creswell, 2003). Reflecting on the four alternative knowledge claim positions put forward by Creswell (2003); Post positivism, advocacy/participatory, constructionism, and pragmatism, the author considered how constructionism and pragmatism aligned best with the study. Concerning constructionism, there are several assumptions identified by Crotty (1998) in relation to socially constructed knowledge claims:

1. Meanings are constructed by humans as they interpret the world and qualitative researchers have a tendency to favour open-ended questions so these views may be expressed.
2. Humans engage and make sense of the world based on their historical and social perspective.
3. The basic generation of meaning is always social and the process of qualitative research is largely inductive. Rather than starting with a theory as is the case in post-positivism, in constructivist research the inquirer generates a theory or pattern or meaning from the data

While the author felt that her own ontological assumptions aligned with socially constructed knowledge claims, she identified pragmatism a second appropriate epistemological outlook in relation to the study. The pragmatic paradigm was pioneered in the work of Peirce, James, Mead and Dewey, who were constructionist and critical (Cherryholmes, 1992) and more recently in the work of Murphy and Murphy (1990), Patton (1990) and Rorty (1993).

There are many forms of pragmatism and in general knowledge claims arise from actions, situations and consequences rather than antecedent conditions as in post-positivism (Creswell, 2003). Pragmatism is essentially a practical rather than ideological epistemology, as Denscombe (2008) states it is "practice driven" (p.280), concerned with "what works" (Patton, 1990).

Creswell (2003) argues that pragmatism is a sound philosophical underpinning for mixed methods studies as instead of an emphasis put on methods, the problem itself is more important and researchers use multiple approaches to understand the problem. Mixed methods research recognizes that the world is not exclusively quantitative or qualitative but a mixed world (Cohen, Manion, & Morrison, 2013), or to put it simply: "Neither life nor research is simply about numbers" (Creswell, 2013).

These assumptions and beliefs affect all stages of this study, from choosing and reviewing literature to formulating research questions and methodological considerations. To that end, criticisms of a pragmatist paradigm have been considered by the author. A primary concern is that underneath the paradigm of mixed-methods research, are the existing paradigms of qualitative and quantitative research which differ in their ontology and epistemology, thus to mix these traditions is to potentially to dilute them (Cohen et al., 2013). In light of this, mixed-methods studies must adhere to a distinct mixed-methods strategy subject to criteria (Creswell, 2003). The strategy chosen for this research is discussed in detail in section 1.3 (Methodology Overview).

1.2.3 Role in the Research

This study involved the design, delivery and evaluation of a computer science outreach intervention for adolescent girls. The author held dual roles as workshop facilitator and researcher in the study. As such, this study can be considered an example of insider research "conducted within a social group, organisation or culture of which the researcher is also a member" (Greene, 2014). However, the author considers that her role was in fact that of an "insider" and an "outsider" during the research process: an insider in that she was directly involved in the nature of the research intervention, yet still an outsider in that the roles of participant and facilitator are defined by social boundaries and protocols.

During the workshops the primary role of the author was to facilitate the workshops. The author freely discloses her enthusiasm as a facilitator which she considers to be both an expression of her "teacher persona" and a belief in the potential of the workshops to have a positive effect on participants. Consideration was given to how data would be collected during the workshops: directly before and after the intervention (not during the workshops), and the data was not analysed for a period of time following collection to allow author time to "swap hats" from practitioner to researcher. Participants were encouraged to be completely honest in their responses, particularly in the qualitative data, even if they had a negative experience on the programme. The intervention was repeated 43 times which gives greater reliability to the study and participant responses, as does the large sample size (n=856).

While analysing data the author made every effort to remain objective, conscious of her own biases and positionality and committed to a process of reflexivity by systematically reflecting her role in the inquiry. The limitations that relate to the author's role in the research and additional measures taken to improve objectivity will be discussed in Chapter 5 of the dissertation (Methodology).

1.3 Methodology Overview

1.3.1 Methodological Approach

With regard to the research problem this study seeks to address: examining the impact and design elements of a CS outreach programme for girls, the author chose a mixed methods approach as a means of meaningfully combining elements of both quantitative and qualitative methods. This research draws on data that is quantitative in nature in order to ascertain whether changes in key attitudinal and intentional variables emerged through participation in the intervention. An examination of how these changes occurred however, required more interpretive method to uncover factors and perspectives on the central phenomenon under investigation and provide a means to uncover causal relationships.

1.3.2 Research Design

This mixed-methods study was designed with both a short-term and a longitudinal element.

The rationale to include both short-term and longitudinal components to the design was in response to criticism of the outreach space from a research perspective, in particular a lack of longitudinal studies to evaluate the impact of interventions (Decker et al., 2016). While longitudinal research is useful that it can enable a researcher to establish causality and to make inferences (Cohen et al., 2013), to highlight constants and changes over time in respect to one or more variables, and identify long-term or "sleeper" effects (Ruspini, 2002), the nature of this research poses a number of distinct challenges. Primarily, longitudinal studies suffer from participant attrition (Ruspini, 2002), in order to accommodate this it is recommended that a longitudinal study should start with as large a sample as is practical and possible to allow for drop-out (Wilson, Huttly, & Fenn, 2006). The second concern in relation to longitudinal studies is that of establishing causation as "the roots and causes of the end state may be multiple, diverse, complex, unidentified and unstraightforward to unravel" (Cohen et al., 2013, p. 273). The author wishes to acknowledge these concerns before presenting an overview of the research design and a further discussion on the challenges of longitudinal research with the responsive measures taken is provided in Chapter 5 (Methodology) of this dissertation.

Figure 1 below illustrates a mixed methods concurrent nested strategy, an approach that is identifiable by data collection phases[6] in which qualitative and quantitative data are collected simultaneously with one method embedded within a predominant method (Creswell, 2003). A concurrent nested model can serve a variety of purposes such as enabling the researcher to address a different question with the nested method than that of the dominant method, to seek information at different levels (Tashakkori & Teddlie, 1998), or to gain broader perspectives as a result of using multiple methods than that of the dominant method alone (Creswell, 2003). Morse (1991) notes that a predominantly qualitative design can embed quantitative data to enrich the description of a cohort of participants or likewise qualitative data could describe an aspect of a quantitative study that is not readily quantifiable.

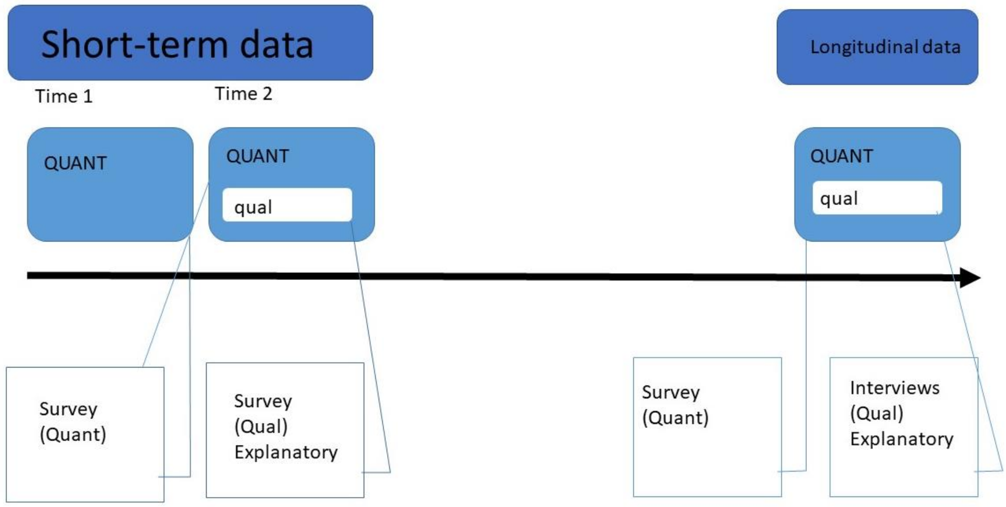

Figure 1: Concurrent nested strategy layered over longitudinal study

To revisit the research questions within the context of this strategy design:

RQ1: What is the short-term effect of the intervention's approach?

RQ2: What are the longitudinal effects of the intervention's approach?

RQ3: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term and longitudinal change?

The author proposes that these questions may be answered through the application of the strategy proposed with the quantitative data answering the "what" and the qualitative data answering to the "how". Underneath the timeline are boxes indicating data collection tools that will be utilized in the process. These will now be presented in the following sub-section.

1.3.3 Research Methods: Data Collection Tools and Analysis

[6] Time 1 and Time 2 labels in short term data collection stage indicate use of same instrument pre and post-intervention to measure key attitudinal and intentional variables.

The research instruments employed in this study include both quantitative and qualitative questionnaires, and qualitative interviews. Table 1 provides an overview of the research instruments and analysis at various stages of the study .The author designed the instruments with the exception of the pre and post-workshop participant survey (Sullivan et al., 2015).

Stage	**Time 1**	**Time 2**	**Time 3**	**Time 4**
Data lead	Quant	QUANT + qual	Quant	Qual
Research Instrument(s)	Validated survey tool	Validated survey tool + open question survey	Researcher designed longitudinal survey	Individual Interviews
Analysis	Summary and Descriptive Statistics Factor analysis	Summary statistics Factor Analysis Paired-t testing + Content Analysis	Summary and Descriptive Statistics	Holistic and Causation Coding Analysis
N (actual or *anticipated*)	N= 856	N= 856 (QUANT) N= 4 18 (qual)	*N= 75*	*N=4*

Table 1: Summary of research instruments, analysis and samples

Short-term quantitative data was collected through a validated survey instrument (Sullivan et al., 2015) measuring personal attitudes towards studying computer science, perceptions of and stereotypes held regarding computer science and self-efficacy with regards to computer science. The survey was administered to participants directly before and directly following the 4-day workshops. Versions of the survey were created using the online Surveymonkey tool (2015-2018) followed by Qualtrics (2018-2020). Data from the survey were analysed by comparing time 1 and time 2 responses using the SPSS statistical software package.

Alongside this tool, qualitative data was collected via open-ended questions on an additional reflective-style handwritten survey. The purpose of the survey was to provide additional and contextualised data from participants' perspectives to triangulate findings from the quantitative instrument. The reflection consisted of a number of open-response prompts to invite responses from participant experiences. The data from this instrument was transcribed to a digital format for analysis with Nvivo qualitative analysis software.

A longitudinal survey was designed based on both findings from the literature and short-term data analysis from this study. The administration of this survey was designed to coincide with the period when participants are typically making their college applications, typically two years following their participation in the intervention. The survey was designed to capture:

1. Student college course preferences and choices related to CS, computing and related courses.

2. The factors that are related to course preferences as perceived by the participant.

3. CS experience outside of CodePlus in the school and non-formal space. Personal interest in computing, family and other peer influences and other mediating factors that may contribute to a decision to study CS or not.

4. Participants' level of engagement with the CodePlus programme and the impact of CodePlus elements on choosing or not choosing a CS related course.

Analysis of data collected via the aforementioned instruments further informed the structure of and content of the interviews protocols. Four individual interviews were conducted with participants who were either studying or intending to study CS at college.

Content analysis, holistic, and causation coding was used to analyse the qualitative data collected. Content analysis "defines a strict and systematic set of procedures for the rigorous analysis, examination and verification of the contents of written data," and it is a process for making replicable and valid inferences from the text (Cohen et al., 2011, p. 563). Content analysis involves coding, categorizing the units of analysis, comparing, and drawing theoretical conclusions (Cohen et al., 2011). A systematic process for performing content analysis (Ezzy, 2013), was followed in this study Regarding the interview data, a less deductive approach was taken with several first cycle coding techniques (Saldaña, 2013) used to analyse the data. A detailed description of the data analysis is provided in Chapter 5 (Methodology) of this thesis.

1.4 Contributions

This thesis makes both academic and practical contributions to computer science outreach and the broader area of addressing gender imbalance in the field. The four main contributions of the thesis in relation to addressing the research problems and research aims are; a structured meta-analysis of the all-female outreach space, a framework for short-term and longitudinal outreach evaluation, a deeper understanding of how pedagogical approach to CS outreach affects participants and further examination of the principal aspects of CS outreach that affect girls.

Table 2 demonstrates the links between the problem statements (PS1, PS2), research aims (RA1, RA2, RA3, RA4) and research contributions (C1, C2, C3. C4).

Problem Statements (PS)	
PS1: Limited research on the impact of all-female computing outreach programmes (particularly longitudinal).	PS2: Role of pedagogy in computer science outreach under-explored.

Research Aims (RA)			
RA1: To develop a meta-analysis of relevant research studies in the area of all-female computing outreach.	RA2: To develop a framework for assessing both the short-term and longitudinal impact of computer science outreach programmes for girls.	RA3: To gather and analyse data on the role of pedagogy in the design and delivery of all-female computer science outreach programmes that may contribute to improving key attitudinal and intentional variables .	RA4: To determine other principal aspects of the design and delivery of all-female computer science outreach programmes that may contribute to improving key attitudinal and intentional variables .

Contributions (C)			
C1: Structured meta-analysis of the all-female outreach space. (PS1, RA1, RA3)	C2: Framework for short-term and longitudinal outreach evaluation. (PS1, RA2)	C3: Deeper understanding of how pedagogical approach to CS outreach affects girls S2, RA3)	C4: Further examination of the principal aspects of CS outreach that affect girls (PS1, RA4)

Table 2: Alignment of Problem Statements (PS), Research Aims (RA) and Contributions (C)

1.5 Structure of Thesis

Following this introductory chapter this thesis is structured into eight chapters: (2) Literature Review, (3) Meta-Analysis of All-Female Outreach Space, (4) Design, (5) Methodology, (6) Short-term Data Findings and Analysis, (7) Longitudinal Data Findings and Analysis, (8) Discussion and Conclusions.

2 Literature Review

2.1 Chapter Overview

This chapter situates the research study within the broader historical and scholarly context of women in computing. A history of the role of women in computing is given, as is a timeline that documents the steady decline of female participation in the field. With the relevant background set, the review will then report on academic literature concerning key themes linked to women's underrepresentation in computing and relate the study to prior research and initiatives of interest. By following this structure, the review sets out to identify and analyse the key issues of the field (Cohen et al., 2013), and to justify the need for this study as a valid contribution to the body of ongoing research on the topic.

The chapter begins with an outline of the literature review process. Sections 2.3 and 2.4 presents the literature on the influencing background, the gender-digital divide and its implications. Section 2.5 explores the key factors that purportedly affect women's interest (or lack thereof) in computing pathways. Section 2.6 explores the strategies and approaches taken at multiple levels to address women's underrepresentation in the field.

The chapter concludes with a summary section, capturing the major themes of the literature, conceptualising the research available on all-female outreach and ultimately arguing the case for the research study undertaken.

2.2 The Literature Review Process

2.2.1 The Literature Search

Creswell (2003) states that a literature review involves locating and summarizing studies concerning a particular topic. Often these are empirical research studies related to the proposed study undertaken, however, there are other types of literature such as thought-pieces, conceptual articles and theoretical literature that may be synthesised into an ongoing, cumulative argument that leads to a conclusion (Cohen et al., 2013).

It should be noted that a literature review is not merely a descriptive summary but an organised and developed argument that presents, contextualises, analyses, interprets, critiques and evaluates its sources (Cohen et al., 2013).

While there is no definitive way to conduct a literature review, many researchers proceed in a systematic fashion as outlined in seven steps by Creswell (2003);

1. Step 1: Identify key words useful for locating materials. These key words may emerge in identifying a topic or result from preliminary readings.
2. Step 2: Using key words begin the search for materials. Creswell suggests initially focusing on journals and books related to the topic in peer-reviewed social-sciences databases.
3. Step 3: Locate approximately 50 research reports which are relevant to the topic, as journal articles and books are the easiest of the texts to locate and obtain these should be prioritised.
4. Step 4: Using the initial group of articles, select those which are central to the topic. By engaging in a process of "abstracting" studies, the researcher obtains a sense of whether the text will make a useful contribution to their understanding of the literature.
5. Step 5: As useful literature is identified, designing a literature map conceptualises a visual representation of the research literature on the topic. A literature map is a valuable tool for positioning one's own research within the broader body of literature on a topic.
6. Step 6: While organising the literature into the literature map, draft summaries of the most relevant articles and include precise references in the appropriate style.
7. Step 7: Upon summarising the literature, assemble the literature review either thematically or conceptually. End the literature review with a summary of the major themes found in the literature and put forward an argument for further research on the topic along the lines of the proposed study.

   The author followed this process at the outset of the study, and took further guidance from Creswell (2003), in establishing a system of prioritising literature while searching:

   1. The author began with a broad syntheses of the literature and sought out summaries of literature on the topic in journal articles and books.
   2. Following this step, the candidate looked for research articles published in peer-reviewed journals on the topic. The candidate began with the most recently published articles and worked backwards which allowed her to use the common technique of "snowballing" whereby one uses the bibliographies of the sources to find other related references (Petticrew & Roberts, 2008; Ridley, 2012).
   3. The candidate then turned to books she could find related to the topic, beginning with research monographs on the scholarly literature followed by books and chapters on relevant single topics.

4. This was followed by a search for conference papers on the topic, prioritising major and international conferences. As with the journal papers, the candidate started with the most recent papers which could report on the most up-to-date developments (Creswell, 2003) and also provide references to more sources of interest.
5. Creswell (2003), places dissertations last in the order of priority but recommends that a researcher search for abstracts if time permits. This is because such texts have a tendency to vary greatly in quality and can be difficult to obtain. Finally, Creswell offers that other materials such as website articles and other “grey literature” can be useful, but cautions that such sources should be evaluated carefully for validity and reliability before inclusion.

The literature search began with guiding questions arising from the author’s experience, but was ultimately an iterative process. As the process of reading and reviewing progressed, search terms were modified and adapted and the parameters for inclusion criteria were drawn. Early in the process the overarching guiding question was “What are the key themes relevant to women’s under-representation in computer science?”. Posing this question led to a directed line of inquiry through the literature canon (Dixon-Woods, Agarwal, Jones, Young, & Sutton, 2005) which is illustrated in the literature map, annotated by subsequent guiding questions. The review first situates the study in the broader literature context, informs the problem statement and ultimately sets out the foundation for the design of the learning intervention.

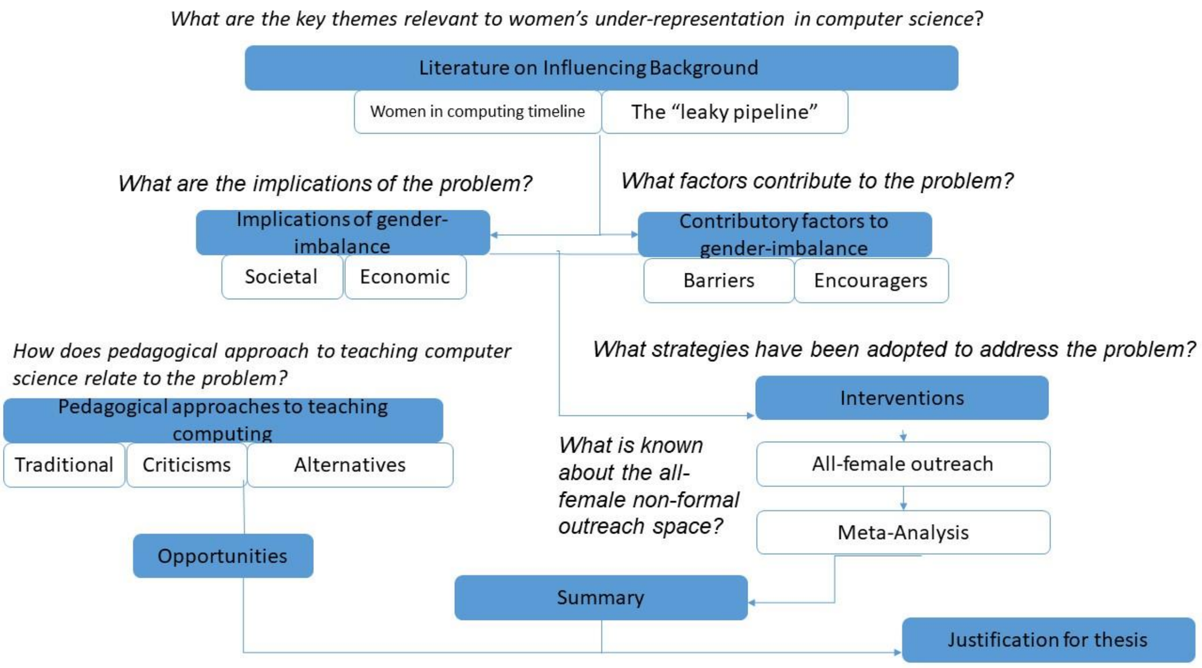

Figure 2: Literature Map

As presented in Figure 2 guiding questions emerged throughout the course of the literature review process. An initial broad-form question to explore the key themes of women’s underrepresentation in computer science led to an exploration of the historical and societal context of the problem. Two further questions then emerged from this process which were “what are the implications of the problem?” and “what factors contribute to the problem?”. Once established that there were both societal and economic ramifications for gender imbalance, and that there were a number of identified key contributory factors, the author investigated the approaches taken to addressing the problem. At this point in the process, the author identified an adjacent topic of interest: "pedagogical approaches to teaching computer science", finding that relatively little has been written about the topic as a contributory factor of women's underrepresentation, and certainly not in relation to outreach activities. Thus the question was posed "How does pedagogical approach to teaching computer science relate to the problem?" which led to an exploration of literature concerning criticism of the traditional approach and alternatives. Given the nature of this study, the review of previous approaches chiefly concerned all-female outreach activities in the non-formal learning space. It was through this review that the candidate identified an opportunity to conduct a meta-analysis of activities in the space, particularly research studies, to answer the question "what is known about the all-female, non-formal outreach space?". The findings from all topics and sub-topics were then summarised, capturing major themes and justifying the design of the research intervention.

2.2.2 Inclusion and Exclusion Criteria

The theoretical literature related to this study (gender, self-efficacy, career and college pathways) is considerable and extends far beyond the themes of this research across multiple disciplines. For example, while gender imbalance is at its most disparaging in the area of computing, it is a long-standing issue in broader field of Science, Technology, Engineering and Mathematics (STEM). Theories and theses most relevant to women and computing were interpreted, analysed, and critiqued, notwithstanding an appreciation of the same issues that have been raised in the literature that concerns the broader STEM context.

With regards to empirical research studies, the author was required to explore the field of all-female outreach activities in the non-formal learning space, in particular their design and their findings. What the candidate found was a mix of both research and non-research based interventions that have taken place or continue to run in a range of countries worldwide. The decision to omit a number of significant all-female outreach programmes such as CoderDojo Girls, Girls Who Code, or Black Girls Code from the review was taken given the difficulty in finding peer-reviewed research data. A meta-analysis of all-female outreach programmes is provided in Chapter 3 with a commentary on both the impact and challenges associated with non-research based programmes.

It is also important to note that the author did not include mixed-gender outreach programmes in her review of empirical research studies. The candidate does not discount the role that such programmes play in encouraging girls' participation in the field, but merely sought to focus the research on all-female learning environments. There is some recent research published on the characteristics of studies in the broader, non-gender specific computing outreach space (Decker, McGill, & Settle, 2016), which in turn provided a framework for the author's meta-analysis of all-female programmes. Equally, the author does not reject the role that formal computer science education likely plays in encouraging girls' future interest in the subject either in single or mixed-gender schools, however to include empirical data from such studies deviates from this research based on outreach in the non-formal learning environment. The candidate used a version of the PICO (Population, Intervention, Comparison, Outcomes) model, which is widely used in systematic review (Petticrew & Roberts, 2008).

The candidate did not set pre-determined parameters on the time of publications while searching for empirical data. This strategy was to ascertain the history of publications related to the all-female outreach activities and to examine possible trends in the concentration of publications over time. 46 publications were observed from 1996-2020 inclusive and a thorough report on how this literature was collected, organised and analysed is given in Chapter 3.

In terms of theoretical data, the candidate followed a strategy of identifying seminal work by working back through the literature search. The report "Why are there so few female computer scientists?"

(Spertus, 1991) was one of the first to highlight diminishing numbers of women enrolling in college computer science programmes which had been in steady decline since the mid-1980s. Thirty years later, the question posed by Spertus continues to be asked by academics, researchers and stakeholders alike, essentially becoming a field of study in its own right (Vitores & Gil-Juárez, 2016). Accordingly, the candidate's range of theoretical literature is largely comprised of texts from the 1990s to the present with some exceptions such as theory on self-efficacy (Bandura & Adams, 1977) and social constructivism (Vygotsky, 1980).

There is no definitive set of rules for establishing inclusion and exclusion criteria in a literature review and therefore there are a number of limitations to this chapter. The candidate recognises that there may be relevant texts that have been missed as it would be pragmatically impossible to include an exhaustive review of all empirical and theoretical research on the topic. The candidate contends that despite this inherent limitation this chapter provides a representative selection of the literature available and defends her strategy for selection on the basis of "theoretical saturation" (Petticrew & Roberts, 2008), which is to say that the process has reached a point of "data saturation, where no further perspective or schools of thought are added by further acquisition of articles" (Petticrew &

Roberts, 2008, p. 101).

2.3 Literature on Influencing Background

2.3.1 Women in Computing: A Historical Perspective

Given the present landscape of the technology industry, it is hard to comprehend that women were among the field's earliest pioneers and the first programmers of digital computers. This section provides a brief history of the role of women in computing preceding digital technology, to the programmable ENIAC computer, the post-war era of business computing, the advent of the personal computer in the late 70s, the tech-boom of the mid-90s and the ever expanding horizon of computers in society. The section documents the notable contributions of individual pioneering women and the rise and fall of the representation of women in computing.

In an age before electronic machines, what we now understand the noun "computer" to mean referred to a human person who performed calculations by hand, and as late as the 1960s was a job description. Renaissance astronomers, maritime navigators in the 18th century and meteorologists in the 1900s typically engaged "computers" to assist with their scientific endeavours as this aspect of the work was both time-consuming and tedious (Grier, 2013). Apart from some notable exceptions such as Mary Edwards of the British Nautical Almanac (Croarken, 2003) and Maria Mitchell (Grier, 2013) who became an astronomer in her own right, women were not typically used as computers until after the mid-1800s. The "Harvard Computers" were a team of women who processed astronomical data at the Harvard Observatory under director Edward Charles Pickering from 1877 to 1919. As the volume of astronomical data to be processed was so vast, the motivation of Pickering to employ an all-female team was likely economic, as women were paid a fraction of their male counterparts' wages thus more computers could be employed with some women even volunteering to work without pay to gain experience in the field (Sobel, 2016).

Over a century before electronic computers became a reality, the English mathematician Ada Lovelace is renowned with the distinction of writing the first computer program (Hollings, Martin, & Rice, 2018). The inventor Charles Babbage had been designing his "Analytical Engine", made of metal gears with the ability to execute conditional commands and store information in memory. In the 1840s Lovelace composed an algorithm for Babbage with which the machine would calculate the Bernoulli sequence of numbers, envisioning the colossal potential of such a device beyond rote calculations. While Babbage's machine was never built and the program never tested, this algorithm is widely considered to be the first published program intended to be executed on a computer (Kim & Toole, 1999). One hundred years after her death, Lovelace's notes on the Analytical Machine were re-published in 1953 in B.V. Bowden's "Faster than Thought: A Symposium on Digital Computing Machines" (Bowden, 1953), in recognition of her contribution to early computing.

The first and second world wars of the 20th century warranted the use of human and early electrical computers in the areas of ballistics, codebreaking, and nuclear fission. These developments in science accelerated by wartime ran in parallel to the depletion of the traditional male workforce called to join the ranks and women were needed to take on new roles. Typically the human computers who calculated tables in the great war were male, but ballistics computing had become feminised by WWII and in the USA women were almost exclusively hired to work in the laboratories (Light, 1999). The ENIAC was the first programmable electronic general purpose digital computer developed primarily for calculating firing tables (Goldstine & Goldstine, 1946) with an all-female programming staff. Light (1999) states that "ballistics computation and programming lay at the intersection of scientific and clerical labour" making the job acceptable from a societal perspective for women despite the often underappreciated high level of mathematical skills required. In Britain, Bletchley Park housed the Government Code and Cypher School (GC&CS), a major centre of allied code breaking during the second world war with mathematician and pioneering computer scientist Alan Turing counted among its staff. Over three quarters of the 10,000 personnel employed by the operation were women, many holding degrees in mathematics, physics and engineering skilled in performing calculations and operating the Colossus computer (Light, 1999).

Following the second world war, human computers aided NASA's predecessor the National Advisory Committee for Aeronautics (NACA) in flight research. Among these workers were African American women, some of whom had been hired as early as 1940 (Evans, 2020). Shetterly (2017) documents the lives of Katherine Johnson, Dorothy Vaughan and Mary Jackson, mathematicians employed by NACA in her biographical book " Hidden Figures: The American Dream and the Untold Story of the Black Women Who Helped Win the Space Race". When electronic computers were first introduced into the space program their results were not always reliable and human computers acted as a backstop (Malcom, 2020). During Johnson's career she calculated trajectories, launch windows and emergency return paths for the first American missions to space. It is astonishing even at the heights of space exploration, that computing was often still demeaned as "women's work" in the 1950s and 60s (Shetterly, 2017), and Johnson initially fought hard both to be included in the team meetings dominated by white male colleagues and to be credited for her work in written reports (Shetterly, 2017). At that time women in government positions experienced economic inequality in title, salary, and limited opportunities for promotion which was compounded by the racial inequalities and the state laws that enforced racial segregation in the workplace (Malcom, 2020). Despite these challenges Johnson's respected reputation among the astronauts and engineers with whom she worked has been described as a "triumph of meritocracy" (Shetterly, 2017).

In the 1950s and 60s when companies began relying on software to process payrolls and crunch data the demand for programmers in the private sector grew quickly. At this time candidates typically didn't need any prior experience but employers hired workers who were logical, mathematical and meticulous before training them on the job (Thompson, 2019). Conversely, gender stereotyping may have worked in women's favour in securing these jobs as some companies argued that aspects of traditional housekeeping experience such as knitting and weaving nurtured an aptitude for programming (Thompson, 2019). The 1968 book "Your Career in Computers" suggested that people who liked following recipes from cookbooks would make good computer programmers (Fischer, 1968), and a 1957 recruitment brochure from IBM titled "My Fair Ladies"[7] specifically targeted women for programming jobs.

Marriage bars and legal obligations for women to leave employment once they had children were still commonplace in western society up until the 1970s (Borjas & Van Ours, 2010). In the USA, Elsie Shutt had begun her career as a programmer on the ENIAC, but when her first child was born in 1957 state law forced her to leave full-time employment (Abbate, 2012). Shutt then founded a freelance consultancy company, training and hiring other stay at home mothers as part-time programmers who could work at night. In Britain, a similar company was set up by Stephanie Shirley in 1962 outside of London. This concept was a progressive step in terms of highlighting a previously unvalued human resource and asserting the role of women in the workplace, although the initiatives received some backlash. A 1963 Business Week article condescendingly referred to Shutt's company as "the pregnant programmers" (Abbate, 2012), while Shirley recalled[8] reading "writing computer programs in between feeding her baby and washing the nappies" in a 1964 newspaper article describing her role as director of a fledgling company.

By the late 1960s women programmers in the American workplace were commonplace and a 1967 article "The Computer Girls" in the popular women's magazine Cosmopolitan was published[9].

[7] https://www.ibm.com/ibm/history/witexhibit/wit_decade_1950.html
[8] https://blankonblank.org/interviews/dame-stephanie-shirley-survival-code/
[9] https://www.siliconrepublic.com/people/women-in-technology-the-computer-girls-cosmopolitan

Photographed in the article is a young woman dressed in the typical glamorous style of the era posing beside the computers. The article published that women could make over US$20,000 a year programming (equivalent to $155,000 in 2021[10]). Abbate (2012) notes that nearly all other professional fields at the time with this level of potential income admitted few women and this was a rare opportunity to earn lucratively.

To identify a point in time when the representation of women in computing waned, the author examines the developments in academic computer science and the shift to personal computers in the later decades of the 20th century.

Computer science was first established as a distinct academic discipline in the 1950s and early 1960s (Denning, 2000). In the USA men were initially more likely to enrol until the 1970s when computer science was the fastest growing choice of college major for women among STEM disciplines (Hayes, 2010b), the proportion of degrees conferred to women peaked at 37%[11] in the 1983/84 academic year but from 1984 onwards the percentage of women began to drop steadily. In 20 years women would make up around 20% of graduates, in 30 years it was just 18%[12] and other western countries showed a similar declining trend (Vitores & Gil-Juárez, 2016).

Interestingly this decline coincided with the time that personal computers began appearing in the home. Prior to the mass production of the microprocessor in the 1970s, computers were prohibitively expensive to the general public but by 1981 it was estimated that over 600,000 American households were in possession of a home computer[13]. Personal computers and games consoles were heavily marketed at men and boys (Kiesler, Sproull, & Eccles, 1985; Klawe, 2002; Margolis & Fisher, 2002; Spertus, 1991), thus boys were far more likely than girls to receive them as gifts, to have greater access to the home computer, and to be initiated into computer use by their fathers (Margolis & Fisher, 2002; Spertus, 1991).

Up until this time, it would have been rare for entrants to computer science degrees to have had any prior experience as computers were cumbersome and expensive machines confined to offices and laboratories. The arrival of personal computers to the home meant that in courses where once all students had all begun as novices, programming enthusiasts with years of experience were arriving. Given the gendering of home computers it is not surprising that these students tended to be men. In a seminal report on the experiences of computer science undergraduates of the mid 90s at Carnegie Mellon University, Margolis and Fisher (2002) found that “before entering college, women have significantly less hands-on experience with computing than men” and ”significant gender differences in attitudes and experiences with computers appear at the earliest ages”.

The rising popularity of computer science courses created a capacity challenge for universities (Roberts, Kassianidou, & Irani, 2002). In response, entry courses were often introduced that students needed to pass before being accepted to a CS major. These gatekeeper solutions coupled with departments under pressure to cover course material at speed to accommodate more classes served to weed-out the students with less prior experience. Of such attempts made by institutions to manage demand Roberts et al. (2002) wrote: “such strategies have a disproportionately negative effect on enrolment by women and minorities”.

For women who did get through these hurdles, they were now heavily outnumbered by the men and often subject to a culture of misogyny in computer science departments (Spertus, 1991). Chauvinistic

10 https://smartasset.com/investing/inflation-calculator
11 https://nces.ed.gov/programs/digest/d12/tables/dt12_349.asp
12 https://nces.ed.gov/programs/digest/d19/tables/dt19_325.35.asp
13 https://archive.org/stream/byte-magazine-1983-01/1983_01_BYTE_08-01_Looking_Ahead#page/n175/mode/2up

behaviour was rife as Spertus documents in her report of the experiences of over 1000 female computer scientists the early 90s. Women faced a paradoxical stigma in that they could either be regarded as less capable in computing ability among their male peers or be penalised for displaying "male" characteristics such as assertiveness and ambition (Spertus, 1991). Issues with "locker-room" culture in CS departments were recognised by Carnegie Mellon University in "Dealing with Pornography in Academia: Report on a Grassroots Action" (CMU, 1989) and Spertus reported on the high incidence of sexual harassment that female computer scientists experienced in the college and work environment (Spertus, 1991).

While the academic computing environments of 1980s and 90s were ostensibly pushing women away, it is suggested that the professional workplace had already taken measures to exacerbate gender imbalance in computing as early as the late 1960s (Ensmenger, 2012). The old status quo of hardware and software was now inverted and male programmers sought to increase their prestige while companies were hiring programmers they could envision in managerial roles. Ensmenger writes that the increasingly popular practice of personality profiling was biased in favour of male applicants. Profiling served to identify job applicants who were the ideal programming "type". According to test developers, successful programmers had most of the same personality traits as other white-collar professionals of the time, but with the crucial distinction that programmers displayed "disinterest in people" and that they disliked "activities involving close personal interaction." It was these personality profiles, that originated our modern stereotype of the anti-social computer geek (Ensmenger, 2012).

Increasingly into the 80s and 90s depictions of computer scientists in popular culture would reinforce this "geek" and "nerd" stereotype of the socially inadequate and isolated male, solely fixated on technology and computing (Margolis & Fisher, 2002; Schott & Selwyn, 2000). In the 1990s the model of "culture-fit", a practice of hiring candidates based on the alignment of their values and behaviours with that of the company was enthusiastically embraced by corporate America (Aycan, Kanungo, & Sinha, 1999). In tech companies this practice led to a self-perpetuating cycle that was devoid of diversity (Hewlett et al., 2008).

As aforementioned regarding the academic field, the "macho" environments of tech companies were often an equally hostile environment for women who were at best isolated and at worst subject to direct exclusionary and harassing behaviour (Hewlett et al., 2008). The Athena Factor: Reversing the Brain Drain in Science, Engineering, and Technology research report describes the distinct "geek culture" in which the awkward archetype often came with a malignant sense of male superiority and arrogance (Hewlett et al., 2008).

College and workplace statistics arguably paint a pessimistic picture for the future of women in computing. The percentage of women employed in computing occupations in the USA has consistently hovered at about 25% since 2007[14] and averaged over member states in the EU, 17% of technology professionals in 2020 were female[15]. Concerning declining numbers of female college entrants (Hayes, 2010a) predicted "If this trend were to continue at the rate experienced from 1986 to 2006, there will be no women bachelor's degree graduates in computer science by 2032. Despite this bleak outlook, there have been a number of positive developments in recent years concerning gender imbalance.

[14] https://www.ncwit.org/resources/ncwit-scorecard-status-women-computing-2020-update

[15] file:///C:/Users/Administrator/Dropbox/My%20PC%20(WINDOWS-7104EJ0)/Downloads/WomeninDigitalScoreboard2020Ireland.pdf

In India, the percentage of women studying computer science and related degrees stands at 40%[16], having climbed sustainably since the early 2000s while the USA saw a decline (Varma & Kapur, 2015). The gender ratios in undergraduate computer science were even closer to parity in Malaysia during this period with women even edging into a marginal majority during some years (Lagesen, 2008). In Israel, the number of female computer science students has doubled in past decade[17] to over 30% of the gender ratio. These outliers go against the grain of the traditional western trends of women's under-representation, adding layers of complexity to the phenomenon by suggesting that the women's disinclination towards computing is neither universal nor biological and more likely to be based on cultural factors.

Following years of low female entry and retention, both Carnegie Mellon University and Harvey Mudd College in the USA made significant changes to their computer science programmes and have enjoyed sustained gender-parity since overhauling their respective courses in the early 1990s and 2000's respectively (Alvarado, Dodds, & Libeskind-Hadas, 2012; A. Fisher & Margolis, 2002). Advances made in the pedagogical approaches and practices in both colleges led to a creating a more welcoming and supportive environment for female students, suggesting that these are factors for other colleges to consider in improving their gender-balance.

According to the US statistics reported, the numbers of female CS graduates grew incrementally from 17.8% in 2013 to 20% in 2018[18], a figure that was last reached over a decade ago in 2005. The UK statistics available from 2015 to 2018 are more modest, In 2015 the percentage of female graduates stood at 16% falling to 15% for the next two academic years, in 2018/19, the percentage increased back up to 16%[19]. In Ireland, the number hovers around 18% from 2014 to 2018[20]. An EU commission report: "Women in Digital Scoreboard 2020" states that on average across its member states 18% of ICT specialists are women, however there is much discrepancy between individual states with Finland, Sweden, Denmark and the Netherlands holding the highest figures of female representation while Bulgaria, Romania, Greece and Italy held the lowest[21].

In the past decade, international bodies such as the European Commission named above and the United Nations have assembled task forces to address the representation of women in the digital economy. Their objectives are not confined to improving the ratios of women in the tech workforce but to address multiple factors that affect an increasing "gender digital divide" (EU Commission 2015, UN 2015). The gender digital divide and the actions taken by high level stakeholders will be discussed in further detail in the following Section 2.3.2 .

In contrast to the aforementioned days of "culture fit", the corporate tech environment has increasingly moved towards a business model for diversity. In 2014 major tech multinationals including Google, Facebook, LinkedIn, and Yahoo released data concerning the demographics of their workforce[22]. Unsurprisingly the reports showed a stark under-representation of women and ethnic groups, confirming the perception of such companies as predominantly white and male. The case for a diverse team is not purely altruistic on the part of company boards, in fact diversity can lead to more committed, better satisfied, better performing employees and potentially better financial performance for an organization (H. A. Patrick & Kumar, 2012).

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[16] https://www.peoplematters.in/article/technology/tech-hiring-in-2021-predicting-the-important-trends-of-the-new-decade-28261

[17] https://che.org.il/en/8-years-number-computer-science-students-doubled/

[18] https://nces.ed.gov/programs/digest/d19/tables/dt19_325.35.asp

[19] https://www.hesa.ac.uk/data-and-analysis/students/outcomes

[20] https://hea.ie/statistics-archive/

[21] https://ec.europa.eu/digital-single-market/en/news/women-digital-scoreboard-2020

[22] https://www.businessinsider.com/diversity-in-tech-2014-2014-7?r=US&IR=T

In the past decade, numerous efforts have appeared offering early intervention activities and programmes directed at encouraging the aspirations of girls and young women in computing. These organisations tend to target girls in adolescence, a time when a drop-off in girls' STEM interest is known to occur (Lapan et al., 2000; Turner et al., 2008). The practices and impact of such interventions set within the wider context of addressing gender-inequality in computer science form the basis of this study with a comprehensive report and analysis of the field offered in Chapter 3.

These developments are all indicators that the under-representation of women in technology is now unquestionably recognised by key stakeholders. However, commitments to address the inequality are often still mere rhetoric as top tech companies have just marginally improved their diversity figures since 2014[23], with the third level statistics reported also improving at a marginal rate. The factors that influence women to enter and remain in the field of computing are complex but what is clear is that the role of women in society and how they are valued has been central to this phenomenon for almost a century.

The following sections will expand on the gender-digital divide, implications for gender-imbalance and influencing factors.

2.3.2 The Gender-Digital Divide

The term digital divide was initially used to describe to a socio-economic divide either within countries, or between world regions, based on the distribution of internet access and other primary technologies (Van Dijk, 2006). An expansion on the theory is now concerned with the divergence of the consumers of digitally created content and technology from the creators of the technology. This is sometimes referred to as second-level digital divide or the production gap (M. Graham, 2011). The "gender-digital divide" acknowledges an emerging global ICT society in which women worldwide do not participate equally due to socio-economic, cultural, religious, and socially conforming factors (Hafkin & Hodame, 2002). With a growing trend towards a more connected and digital world, the ramifications of the divide for women could mean lack of engagement and input into shaping a new kind of economy and society.

In response, the United Nations has developed a framework in line with the sustainable development goals. The Action Plan to Close Digital Gender Gap sets out the framework for critical actions to foster and accelerate inclusive and sustainable development by closing the gender gap and harnessing the transformative potential of ICT for women's empowerment:

"Women's equal and meaningful participation in the digital society is seen as both integral to the realization of women's rights in the 21st century, as well as the realization of a just, inclusive, and rights-based information society and to achieve global objectives around gender equality and women's empowerment by 2030."

(United Nations, Action Plan to Close Digital Gender Gap, 2015).

The plan consists of five main areas for action;

1. Developing gender responsive strategies and policies.
2. Ensuring women's and girls' affordable access to ICT.

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23 https://www.cnbc.com/2020/06/12/six-years-into-diversity-reports-big-tech-has-made-little-progress.html

3. Ensuring girls and women have the necessary skills and knowledge to understand, develop content, participate in and benefit fully from ICTs and their applications.
4. Increasing private and public investments for, and remove the gender barriers to, ICT education and training for women and girls.
5. Building partnerships and platforms for cooperation across nations.

The European Commission has taken a similar stance on addressing the gender-digital divide across its member states. Based on findings from a 2018 study (*Women in the Digital Age*, 2018), the Commission outlined a number of strategies to increase women's participation in the digital sector. The "Declaration of Commitment on Women in Digital" was signed by 27 EU member states in 2019. The declaration pledges members to take action at national level by; establishing a national strategy to encourage women's participation in technology, encouraging broadcasters to promote a positive public image of women in technology, establishing a European Girls and Women in ICT day, holding companies accountable to combat gender discrimination, advancing a gender-balanced composition of boards, committees and bodies dealing with digital matters, and improving monitoring mechanisms and data collection in order to set improved targets. One tool that measures these targets is the Women in Digital Scoreboard[24] that monitors women's participation in the digital economy and society. Part of the Digital Economy and Society Index (DESI), the scoreboard assesses member states' performance in the areas of technology use, specialist skills, and employment based on 12 indicators.

While these reports and policy documents all encompass a far wider issue than the under-representation of women in computer science training and the workforce, it is encouraging to see objectives specific to addressing the problem. Two key action areas in the UN Action Plan; "Ensuring women and girls have the necessary skills and knowledge to understand, participate actively in, and benefit fully from the digital society and that content, applications, services are made by and for women", and "Promoting Women in the Technology Sector, including into positions of Decision-Making" concern the recruitment and progression of girls and women into computing fields. Similarly, the European Commission declaration recognises "that gender stereotyping, cultural discouragement and lack of awareness and promotion of female role models hinders and negatively affects girls' and women's opportunities in STEM studies, related careers and digital entrepreneurship, and lead to discrimination and fewer opportunities for women in the labour market", "given Europe's demographic decline and the increasing demand for ICT practitioners, the increase in the share of women in the ICT sector will be critical in Europe's efforts to build a more sustainable economy and society through digital innovation", and finally emphasises "the cross-sectoral nature of this phenomenon, rooted in conscious or unconscious gender bias, covering the education sector, the portrayal of women in the media and advertising on-screen and off-screen, and the responsibility of the private sector in proactively recruiting, developing and retaining women's talent and instilling an inclusive business culture in their companies." (European Commission 2019).

These developments taken by both the United Nations and the European Union highlight the issue at core of this thesis, the underrepresentation of women and girls in computing. The literature frames the problem as more than merely mining an under-tapped resource to meet the demands of the growing tech industry but as a human rights issue, central to establishing a fair and equal society.

This section outlined the gender digital divide from a human rights perspective and the strategies to address the divide taken by the highest executive levels of governance and diplomatic organisations. The following two sections will expand on both the economic and societal implications of gender imbalance in computing.

[24] https://ec.europa.eu/digital-single-market/en/news/women-digital-scoreboard-2020

2.3.3 Implications of Gender Imbalance: An Economic Perspective

"The business case for inclusion and diversity is stronger than ever. For diverse companies, the likelihood of outperforming industry peers on profitability has increased over time, while the penalties are getting steeper for those lacking diversity"(McKinsey, 2020).

An economic argument for diversity is not confined to CS. Across all industries it is suggested that a diverse workforce fosters better problem solving and innovation that ultimately leads to better products and services for a wider customer demographic (Cox Jr, 1991; Harvey & June, 2012). In a recent report compiling data from over 1000 large companies across 15 countries, the McKinsey Institute asserted that when the representation of women in leadership and executive roles increases, so too do company profits (McKinsey, 2020).

The European Institute for Gender Equality (EIGE), proposes two fundamental economic arguments for increasing the number of qualified female STEM graduates; increasing the labour supply in STEM sectors and increasing women's access to well-paid jobs (EIGE, 2015). A large majority of Member States have experienced severe recruitment difficulties in relation to skilled STEM labour, especially in engineering and IT, with twenty Member States reporting difficulties in finding ICT professionals (Attström, Niedlich, Sandvliet, Kuhn, & Beavor, 2014). At an individual level, fewer women in STEM studies may translate into lower employment prospects and lower earnings in the labour market, ultimately leading to weakened economic independence for women. This is due the accelerated growth and significantly higher wages of STEM fields relative to other industries (European Parliment, 2015). The EIGE claims that increasing the participation of women in STEM subjects will have a strong positive GDP impact at EU level; "Closing the gender gap in STEM would contribute to an increase in EU GDP per capita by 0.7-0.9 % in 2030. By 2050, the increase is between 2.2 % and 3.0 %. In monetary terms, closing the STEM gap leads to an improvement in GDP by EUR 610-820 billion in 2050." (EIGE, 2015).

The McKinsey Global Institute (MGI) have projected that more than half of Europe's workforce will face significant transitions in the coming decade as automation will require workers to retrain or acquire new high-level skills (MGI, 2020). The United States Bureau of Labour Statistics projects that employment in computing will grow 11% from 2019 to 2029, much faster than the average for all occupations in the USA, creating over half a million new jobs.

While the underrepresentation of women and people of colour is at its most profound in STEM, many tech companies have moved to implement strategies for diversity in recent years. In 2014, tech giants including Apple, Facebook, Google, Microsoft, Twitter and Amazon acknowledged the gap by making their employee statistics on gender and minorities public for the first time, pledging to increase diversity in their workforces. At the time of their first annual report on diversity, Maxine Williams, Facebook's Global Head of Diversity stated:

"At Facebook, diversity is essential to achieving our mission. We build products to connect the world, and this means we need a team that understands and reflects many different communities, backgrounds and cultures. Research also shows that diverse teams are better at solving complex problems and enjoy more dynamic workplaces. So at Facebook we're serious about building a workplace that reflects a broad range of experience, thought, geography, age, background, gender, sexual orientation, language, culture and many other characteristics."

Despite the public pledges of Facebook and other major tech multinationals, a recent dossier[25] was critical of their slow pace in achieving gender parity and greater minority representation, although women have moved up as a higher fraction of the workforce in a number of companies. The

[25] https://www.statista.com/chart/4467/female-employees-at-tech-companies/

percentage of women employed by Facebook's technical workforce jumped from 15% in 2014 to 23% in 2019 with similar progress made in Google.

Ostensibly, both policy makers and the private sector recognise the financial motivations for cultivating a gender-diverse workforce. The fundamental, if crude, argument is simply to mobilise human capital to meet the demands of the ever expanding tech workforce. A more sophisticated argument is that by diversifying the workforce, an enterprise will create better products and services to serve the needs of a broader customer base. Finally, by neglecting to ensure their access to vital skills development in the technology, women will at best miss out on high-paying and stable employment or at worst be eradicated from the automated and high tech economy of the future.

The following section will examine the societal based implications of women's underrepresentation in computing.

2.3.4 Implications of Gender Imbalance: A Societal Perspective

"We shape our buildings; thereafter they shape us."

Winston Churchill

Following its destruction during the Blitz, the house debated on how the commons chamber would be rebuilt. After some deliberation it was decided that the chamber's adversarial rectangular pattern would be restored instead of the semi-circular or horse-shoe design favoured by some legislative assemblies. Churchill maintained that the shape of the old chamber was responsible for the two-party system which is the essence of British parliamentary democracy: "we shape our buildings and afterwards our buildings shape us."[26]

While Churchill was reflecting on the relationship between physical architecture and human behaviour, this analogy is equally applicable to technology and society. We shape technology and in turn technology shapes us.

The acceleration of advancements in technology and the ever-growing ubiquity of computers in our lives in has been declared the "Fourth Industrial Revolution", as Schwab (2017, p. 1) writes:

"Of the many diverse and fascinating challenges we face, the most important is how to understand and shape the new technology revolution which entails nothing less than a transformation of humankind. We are at the beginning of a revolution that is fundamentally changing the way we live, work and relate to one another. In its scale, scope and complexity, what I consider to be the fourth industrial revolution is unlike anything humankind has experienced before".

This emergence of a technologically advanced society with the subsequent risk of women losing agency is strongly acknowledged in the pledges of multinational executive and diplomatic organisations (See Section 2.3.3). As computing becomes increasingly embedded into the fabric of society, all genders will use more technology reliant products and services. Schwab (2017) envisions the colossal impact of rapidly developing technologies; Artificial Intelligence, robotics, internet of things, autonomous vehicles, 3D printing and the dawn of quantum computing. Schwab calls attention to the exponential velocity with which these technologies are evolving, attributing this to our multifaceted and deeply connected world where technology begets new technology (Schwab, 2017).

[26]https://www.parliament.uk/about/livingheritage/building/palace/architecture/palacestructure/churchill/

Examining the present gender distribution of software engineers, US data from 2020 reported women made up 19% of the national cohort[27]. In the EU a similar number is reported where women make up under 18% of ICT specialists across all member states. These statistics ultimately point to development teams that are heavily gender-imbalanced, not to mention the greater likelihood of being led by male managers. While some products may be designed primarily for men or women, the majority of technology products are intended to be gender-neutral, however, unconscious bias may go unchecked when teams are homogenous and when gender is assumed not to be relevant to the users tasks it is not discussed (Williams, 2014).

A so-called “gender-blindness” in tech culture is well documented in “Invisible Women” (Perez, 2019), with what the author describes as a “one-size-fits-all-men” approach to design where the average smartphone is too large for the hands (or indeed the pockets!) of the average woman, wearable technology metrics fail to take into account key differences in female anatomy, and virtual reality environments (if indeed the headsets and hardware fit women in the first place) are much more likely to cause motion sickness for female users.

While Perez contends that male biased design in technology is generally unintentional, a fair assumption given the gender breakdown in the target market, she points to gender imbalance on design and testing teams as the cause, or to put it another way: “when we are designing a world that is meant to work for everyone we need women in the room” and “failing to include the perspective of women is a huge driver of an unintended male bias that attempts (often in good faith) to pass itself off as ‘gender neutral’.” (Perez, 2019, p. xiii).

Perez (2019) argues not only of the injustice in women paying the same price for technology that delivers an inferior service but of the potentially harmful safety implications; For example, voice recognition software is “hopelessly male-biased” (Perez, 2019, p. 162), with some recent linguistics research finding Google’s speech recognition software 70% more likely to accurately recognise male speech than female (Tatman, 2016). This failure in design goes far further than a nuisance but as voice-recognition software branches into fields such as automobile and medical technology these errors are potentially critical (Perez, 2019).

The evident cause of inefficient speech recognition software for women is that the technology is trained on large corpora of voice recordings that are dominated by male voices, however, it is not the only example of male-biased databases that produce male biased algorithms (Perez, 2019), with a growing awareness of the effects of bias in machine learning (Leavy, 2018). The ability to create thinking machines raises a host of ethical issues and predictable complications as AI algorithms approach human-like thought (Bostrom & Yudkowsky, 2014). AI is a reflection of human decisions as the data used to train AI is effectively a representation of our experiences, behaviours, and decisions. Some key examples of common AI applications are translation software, web and image searches, and CV scanning software. If the corpora used to train these applications are full of gendered data gaps then machines will not only reflect bias but will amplify it, causing women to be further stereotyped, their writing left uncited, excluded from job interviews, and medically misdiagnosed (Perez, 2019).

Gender differences in approaches to writing and debugging software code were reported in several research studies (Beckwith et al., 2005; Williams, 2014), yet the features of commercial software tools are usually optimized around the preferences of male developers (Beckwith et al., 2005). In any enterprise teams are made up of individuals, each with their own unique perspectives shaped by biological, social and environmental factors. While personal input is an innate element in any design process, there have been some notable differences reported on how men and women offer opinions in teams (Karpowitz, Mendelberg, & Shaker, 2012). Williams (2014) reported that women were less

[27] https://www.bls.gov/cps/cpsaat11.htm

likely to voice opinions during product development that would expose a clear gender-difference. More troubling was Karpowitz et al. (2012) who found a reluctance in women to raise certain issues unless the gender ratio was 60-80% female, yet given the opportunity to raise the same issues anonymously they would have no reservations. This finding was not observed in men.

User Experience Design (UX, UXD, UED, or XD) is one of the top five in-demand skills according to a recent LinkedIn report[28] and global demand outweighs supply for skilled UX professionals[29]. Interestingly, UX design outperforms most other areas of the tech industry in terms of gender parity and in Ireland women account for over 40% of UX designers[30]. Colman Walsh, CEO of the UX Design Institute said of the even split between male and female course graduates: "We see a far more balanced percentage of men and women pursuing careers in UX compared to other areas of technology. Feedback from our student base is that it focuses on the more human side of technology and offers an interesting blend of design and psychology, which requires a lot of empathy for end users."[31] As demand for UX designers grows quickly, these figures are encouraging, nevertheless, advocacy groups for women in the industry such as Why Design[32] and Ladies that UX[33] caution that women are still greatly outnumbered in senior UX roles and left vulnerable to attrition due to home-life pressures.

In summary, there are strong arguments for gender-parity in the design and development of technology beyond corporate or individual monetary gain. As the role of computers in society accelerates, so drives the demand for a highly skilled technological workforce building the digital architecture of life. It is beyond the scope of this literature review to fully examine the ways in which the under-representation of women in such roles will affect society into the future, however the author contents that this broad analysis provides some insight into the societal implications of such a scenario.

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[28] https://business.linkedin.com/talent-solutions/blog/trends-and-research/2020/most-in-demand-hard-and-soft-skills
[29] https://www.uxdesigninstitute.com/blog/want-a-career-in-ux/
[30] https://www.morganmckinley.com/ie
[31] https://www.siliconrepublic.com/careers/ux-design-ireland-increases
[32] http://whydesign.ie/about/
[33] https://www.ladiesthatux.com/

2.4 The Leaky Pipeline: Female Attrition in Computing

"According to a common metaphor, a girl should be entering the pipeline of computing when she enters school, by taking preparatory courses, becoming experienced in the use of computers and thus becoming prepared for undergraduate college degrees in computer science. further along the pipeline – and depending on the educational system – a young woman would major in computer science and after that, she would graduate from a computing discipline. At the end of the educational pipeline – with a bachelor's, master's or doctoral degree in computing – this woman would enter the workforce pipeline, advancing from entry-level positions to more senior positions in the computing field. However, as data show, this pipeline leaks in every junction in almost every western country"

(Vitores & Gil-Juárez, 2016, p. 667)

As cited in previous sections, the "leaky pipeline" is a popular analogy used to conceptualise a drop-off in the participation of women and girls at all stages of a computing career pathway. The metaphor suggests that girls and women are carried along through progressive stages of education and employment from initial interest in the subject to the highest levels of professional leadership and management roles and characterises the problem as a "flow" of women or girls that diminishes over time (Soe & Yakura, 2008). While this research study primarily concerns the adolescent, pre-college age group, it is useful to examine the challenge of enticing more young women towards computing within the context of the overall problem concerning female recruitment and retention. By identifying pivotal stages where a drop-off in motivation occurs, and examining the key factors behind diminishing participation through progressive stages, the design of early intervention strategies and the target demographic can be informed.

It is however important to note that while it is commonly cited, the leaky pipeline metaphor is not universally accepted as a framework within the literature concerning gender and computer science. There are a number of criticisms of the pipeline "lens", primarily that the case for drawing more women to computing is often based on industry shortages (Adam, 2005), or to quote Metcalf (2010, p. 3) "The view of women and people of colour as passive resources to be harnessed not only ignores agency, but it also hides the ways in which certain populations are disciplined, produced, and used for the benefits of others". A second key criticism is that the framework too often categorises women and girls who fail to enter or leave the pipeline as a group of people to be converted in their attitudes and views to fit the established culture of computing, or to put it another way conform to a male standard (Vitores & Gil-Juárez, 2016).

Despite these considered criticisms, the metaphor continues to function as a vehicle of mainstream research and informs policy measures to promote women in computing (Vitores & Gil-Juárez, 2016). The pipeline is convenient visual analogy to demonstrate the lack of women in STEM disciplines (Wolfinger, Mason, & Goulden, 2006), and Soe and Yakura (2008) recommend that instead of rejecting the framework, it should be augmented with a focus on the layers of culture surrounding IT work which would lead to lead to a better understanding of the problem, and more successful interventions (Soe & Yakura, 2008).

Regardless of which lens through which one approaches the problem, research undeniably shows female drop-out at all strata of computing education and careers. Camp (2002) was an early advocate in highlighting not only the low intake and retention of female CS undergraduates but the diminishing proportion of women to the point of near-extinction at professor-level in computing academia. More recent US data shows little change in this trend with far fewer women in faculty computing compared to academia on average (NCWIT, 2020). In the aforementioned Athena Factor Report, an attrition rate of 56% of women in tech roles was reported with a staggering 51% of those women abandoning their training to leave the workforce or take a non-SET job (Hewlett et al., 2008). From data collected, the report attributed the professional drop-out of women in science, engineering and tech (SET) roles to five factors; isolation, macho-culture, reward systems based on risk, a lack of clarity on career pathways, and extreme work-pressures (Hewlett et al., 2008). This data from the US is the most recently available on female-drop out in tech roles (NCWIT, 2020).

In most Western countries, girls and boys are equally engaged in their technology usage with few reported gender differences in terms of internet or social media usage (Ofcom, 2015). A national US survey reported that 59% of girls aged 13-17 played video games on a computer, game console or portable device (Lenhart, Smith, Anderson, Duggan, & Perrin, 2015). These figures are arguably a great leap forward in terms of what was reported 30 years ago regarding access to technology in the home and the marketing of video games at boys. Nonetheless, an increase in girls' technology usage does not translate to an improvement in numbers for secondary school enrolments in computing classes. Recent data from the UK shows a 20% uptake from girls at GCSE level, dwindling to 9% at A-level (After the reboot: computing education in UK schools, 2017), 2012 data made available from the US reported similar statistics with just 19% of Advanced Placement (AP) computer science test takers female. (Ashcraft, Eger, & Friend, 2012). In Ireland, the introduction of computer science as a formal school subject is in its relative infancy, particularly in the senior educational cycle. Data collated by Women in Technology and Science Ireland (WITS), proposes that the gender gap in STEM subjects starts to open up after the junior cycle where roughly equal numbers of boys and girls study science, however in the senior cycle, girls predominate in biology and chemistry and are underrepresented in physics. Much research on investigating female-underrepresentation in computing proposes that secondary school is a pivotal point of "exclusion" and "disaffection, as by this age, gender differences in computing interest and a subsequent lack of interest in computing or IT as a career option is well established (Vitores & Gil-Juárez, 2016).

The factors behind this critical drop-off or early pipleline "leak" purported in both the theoretical and research literature the will be discussed in detail in the following section.

2.5 Factors Affecting Gender Imbalance: Barriers

Research on gender-imbalance in computer science is primarily focused on exploring why girls or women do not enter the pipeline and why they do not persist, advance or remain in the field (Cohoon & Aspray, 2006; Vitores & Gil-Juárez, 2016). Typically, such studies and theoretical literature identify common factors that explain the leaking at each transition point. These factors can be broadly characterised as biological, gender-based, societal, structural and personal.

The following subsections will examine these factors and the consequent barriers to the interest of girls and women in the field of computer science. The relationships between factors and barriers can be both correlative and complex as many studies suggest.

2.5.1 Biological Factors

Drawing on research in endocrinology, economics, sociology, education, genetics, and psychology, there is no conclusive evidence of inherent brain structure differences between men and women to suggest male brains are physiologically optimized to perform mathematical and spatial operations (Ceci & Williams, 2009). To contest this standpoint is potentially dangerous, as one male engineer at Google discovered when he wrote an internal memo entitled "Google's Ideological Echo Chamber," denouncing the company's diversity pledge and arguing that the low number of women in technical positions was purely a result of biological differences. The memo was shared and condemned widely across social media leading to the prompt dismissal of the employee[34]. In his memo, the dismissed employee had quoted the work of prominent clinical psychologist Simon Baron-Cohen who forwarded a theory that the female brain is predominantly hard-wired for empathy whilst the male brain is predominantly hard-wired for understanding and building systems theory (Baron-Cohen, 2003). Unsurprisingly, Baron Cohen's empathizing-systemizing (E-S) theory has a number of strong critics who refute that brain types can be correlated to gender (Eliot, 2011; Rippon, 2019).

It is beyond the parameters of this study to further review the literature in support of or against biological factors that affect gender-imbalance in the field of computing. With that said, the author accepts a position that the body of evidence points to cultural gender roles and sociocultural factors as the cause.

2.5.2 Gender-based and Societal Factors

Gender identity is the personal sense of one's gender (Zucker & Bradley, 1995). In early childhood this understanding is typically anatomical, but also includes feelings about a person's biological sex and behavioural self-presentation as male or female (Berenbaum, Martin, & Ruble, 2008). Most children are capable of labelling their sex by 3 years of age (Berenbaum et al., 2008), and a child's awareness of being either a boy or a girl is considered by cognitive theorists to motivate gender-typed behaviour (Constantinople, 1979; Martin & Dinella, 2002). Stereotypes concerning clothing, activities, toys, and games are known as early 24 months but possibly as early as 18 months (Martin & Dinella, 2002; Miller, Trautner, & Ruble, 2006), and knowledge of child and adult activities and occupations increases rapidly between ages 3 and 5 (Blakemore, 2003). Career preferences are formed early (Poole & Low, 1985) and continue to be influenced by gender (Gerstein, Lichtman, & Barokas, 1988). Children, and girls especially, develop beliefs that they cannot pursue particular occupations

[34] https://www.nytimes.com/2017/08/07/business/google-women-engineer-fired-memo.html

because they perceive them as inappropriate for their gender (Dorr & Lesser, 1980; Looft, 1971; McMahon & Patton, 1997).

Vocational interest patterns vary considerably from childhood to adolescence before gaining relative stability in early adulthood (Betsworth & Fouad, 1997; Swanson & Hansen, 1988) supporting Fagin (1953, p. 172)'s assertion that ''interest patterns are probably neither well differentiated nor very stable before age 15''. It is during this time that children demonstrate a developmental shift in their behaviour where more generalized exploration gives way to a conscious, goal-directed exploration of careers (Hartung, Porfeli, & Vondracek, 2005). Much of the research on the underrepresentation of women and girls in computing indicates that middle school is a key moment of 'exclusion' and 'disaffection' when gender differences in computing careers become well-established (Vitores & Gil-Juárez, 2016). In relation to this this key phase, there are a number of distinct societal factors commonly found in the literature to explain the drop-off in girls' interest. These factors can be broadly grouped into four categories: Personal perceptions and stereotypes held by girls regarding computer science external agents of socialisation (parents, peers, teachers, media).

In respect to the former, the research tends to agree on four sub-categories: (a) The image and stereotypes of computer scientists and people in computer science as awkward, nerdy males who lack interpersonal skills and are obsessed with technology; (b) the related image of computer science as a male-dominated arena oriented towards working not with people but with 'machines'; (c) the poor knowledge and awareness of computer science as a discipline and as a career; and (d) the perception of computer-related subjects as unattractive and/or boring (Vitores & Gil-Juárez, 2016). It is important to note that both genders can hold these perceptions of computer-science, but the influence on career aspirations is arguably more profound in girls than it is in boys (Lang, 2010; Margolis & Fisher, 2002; Papastergiou, 2008).

2.5.3 Stereotypes

Attitudes and stereotypes to computer science remain similar to what they were half a century ago (Berg, Sharpe, & Aitkin, 2018). A lack of social skills and the "geek" or "nerd" persona prevails as the enduring stereotype of a typical computer scientist (Cheryan, Drury, & Vichayapai, 2013; Cheryan, Master, & Meltzoff, 2015; Wong, 2016). Other common stereotypes include the perception that computer science requires innate genius or "brilliance" (Leslie, Cimpian, Meyer, & Freeland, 2015) is heavily male-orientated (Cheryan et al., 2015), and that the nature of CS work is isolating and does not involve teams or working with others (Diekman, Brown, Johnston, & Clark, 2010). Computer science stereotypes are typically transmitted through the media, role models, and physical computing environments (school, colleges, workplaces) (Cheryan et al., 2015). Opportunities to engage in computer science education before college vary greatly by national systems of education, thus many adolescents rely on these cultural stereotypes to form the basis of their understanding concerning careers in the field (Cheryan et al., 2015), with reports that their ideas about what scientists are like are influenced more by the media than by any other source (Steinke et al., 2007). Popular films and television shows depict computer scientists and engineers as mostly White and Asian males who are socially unskilled, and singularly obsessed with technology (Cheryan et al., 2015). The Google CS in Media team was established as a consultancy group to work with writers and producers with a view to creating less stereotyped portrayals of computer scientists in film and television (Smith, Choueiti, Yao, Pieper, & Lee, 2017). The project reported that given depictions of computer science are still rare in popular programming and predominated by white males, viewers would need to watch a great deal of entertainment content before seeing a woman. During the first year of the project, in the Google influenced content, 24.6% (n=15) of CS characters were female, and 75.4% (n=46) were male (a ratio of 3.1 males to every 1 female CS character), the sample of non-

Google influenced content contained no females or characters from underrepresented racial/ethnic groups engaging in CS (Smith et al., 2017). Additionally, the report found that portrayals of computer science in film and television continued to reflect a view of the field rooted in stereotypes, for example showcasing few CS characters who are referenced as attractive, shown in romantic or parental relationships, or who stated prosocial goals for CS use.

Stereotypes can also be transmitted by direct exposure to students and industry professionals who narrowly characterise the field of computer science, in turn discouraging women and girls' interest (Cheryan et al., 2015). One study examined whether a brief exposure to a computer science role model who fits stereotypes of computer scientists had a lasting influence on women's interest in the field (Cheryan et al., 2013). Undergraduate women (n=100), who were not computer science majors met either a female or male peer role model who embodied computer science stereotypes in appearance and stated interests or the same role model who did not embody these stereotypes. Participants and role models engaged in a short interaction lasting approximately 2 minutes. Interest in majoring in computer science was assessed following the interaction and again 2 weeks later outside the laboratory. Results revealed that exposure to the stereotypical role model had both an immediate and an enduring negative effect on women's interest in computer science. Perhaps more interesting was the finding that the gender of the role model had a negligible effect by comparison to that of the stereotype variable and differences in interest at both times were mediated by women's reduced sense of relating personally to a male or female role model (Cheryan et al., 2013).

Correspondingly, learning environments that characterise a stereotypical image of computer science are less likely to entice the interest of girls (Cheryan et al., 2015). An interesting study at Stanford University examined the decisions of undergraduates to enrol in CS majors based on brief exposure to different classroom environments (Cheryan, Plaut, Davies, & Steele, 2009). The study was designed with half of the participants placed in a room with objects that characterised a stereotypical view of computer science majors (Star Trek posters, science fiction books, and stacked soda cans) as determined by a sample of students across multiple disciplines, for the other half of participants the room contained "neutral" objects that the sample did not associate with computer science. The findings reported that women in the room containing the stereotypical objects expressed significantly less interest in majoring in computer science than those in the neutral room even in an all-female sub-group. For men, the environment did not affect their interest in computer science. The study was replicated with high-school students examining photographs of a stereotypical and a "neutral" classroom (Master, Cheryan, & Meltzoff, 2016), the findings showed that classroom that did not project computer science stereotypes caused girls, but not boys, to express more interest in taking computer science classes.

In their research with the CS in media team, Google reported that perceptions of CS account for around 27% of a girl's desire to go into the field (Smith et al., 2017), thus studies on stereotypes provide useful findings. Nonetheless, this is not a silver bullet, as there are other contributory factors that affect young women's interest in pursuing computing pathways.

2.5.4 External Agents of Socialisation

The influence of the media in perpetuating stereotypes and a narrow characterisation of computer science was discussed in the previous section. But what of the other main agents of external socialisation?

Parents can unintentionally create obstacles for their daughters through their own computer attitudes and subtle biases which provide more support for their male children (Gürer & Camp, 2002; Moorman & Johnson, 2003).There are a number of studies that explore how parents can both directly and indirectly influence career choice; by encouraging girls to pursue other studies or to not pursue computing, but also by transmitting stereotypes about girls' lack of capability with respect to computing (Babin, Grant, & Sawal, 2010; Vekiri, 2010; Vekiri & Chronaki, 2008). A Canadian study found that parents have the strongest external influence on their children's post-secondary and career directions in high school (Babin et al., 2010), while Vekiri and Chronaki (2008) found parental support was the factor most strongly associated with Greek primary school children's computer self-efficacy and value-beliefs. The latter study found significant gender differences regarding parental support for computer-use which correlated with the dependant variables. Another Greek study examined similar gender differences across high school students, finding that girls were less likely than boys to pursue computing in college, mainly due to extrinsic reasons (including parental support) as opposed to their personal interest in CS (Papastergiou, 2008). There is some evidence to support the contention that fathers are more likely to condition their son's election of studies whilst mothers are more likely to condition their daughters (Chhin, Bleeker, & Jacobs, 2008; Whiston & Keller, 2004) and that girls raised in egalitarian environments receive better high school grades in science and mathematics (Updegraff, McHale, & Crouter, 1996). An Australian pilot study was conducted to investigate whether more familiarity with information technology and social media would make mothers more aware of IT career paths for their daughters and more positively inclined to recommend such careers (Stockdale & Keane, 2016). While the study was limited by a small sample, it did raise some interesting issues on the influence of mothers and their own personal views concerning computing.

Following the primary role of parents, teachers are influential adults that play a major role in their pupils' choice of studies and academic performance (Sáinz, Pálmen, & García-Cuesta, 2012). Either consciously or subconsciously, teacher–student interaction often varies by the gender of the student (Aukrust, 2008; Jones & Dindia, 2004), and teachers can have different achievement expectations for boys and girls regarding science and mathematics (Fennema, Peterson, Carpenter, & Lubinski, 1990; Li, 1999). Teachers' beliefs and attitudes concerning gender-roles combined with their attitudes and beliefs about technology can subtly steer girls to not study computers (Barker & Aspray, 2006). Vekiri (2010) found that perceived teacher expectations were positively associated with students' ability beliefs and were a significant predictor of students' interest in computing, Furthermore, perceived teacher expectations were more significant for girls' than for boys' computer self-efficacy (Vekiri, 2010). In addition to teacher attitudes and expectations, teachers may influence student attitudes regarding computer science through their pedagogical practices. Teachers can enhance student motivation for learning using pedagogies that provide opportunities for exploration and collaboration, are connected to the real-world, and appeal to student interests (Blumenfeld et al., 1991; Bransford, Brown, & Cocking, 2000; Vekiri, 2010). The role of pedagogical practice in increasing girls' motivation will be further explored in section 2.6.3.

The influence of adolescent peer-support and gender has been studied in relation to the wider area of STEM careers (Robnett & Leaper, 2013). The study found that peer-group support for STEM influenced STEM career interest with group characteristics and participant gender moderating the effects; for example, when friendship groups do not support STEM and are primarily female, girls may find it more difficult to view STEM as compatible with their social gender identity. However, when the friendship group does support STEM, its gender composition may matter less. Peer-pressure for girls to conform to gender-norms regarding computer science is considered to affect their motivation to pursue the subject (Cohoon & Aspray, 2006), while Master et al. (2016) propose girls may avoid computer science as prevailing stereotypes signal to them that they do not belong.

It has been reported that all-female computer science classes at high school may result in better attitudes towards the subject, when compared to mixed classes (Crombie, Abarbanel, & Trinneer, 2002; Kemp, Wong, & Berry, 2019). Crombie et al. (2002) found that girls from all-female classes reported higher levels of perceived teacher support, confidence, and future academic and occupational intentions than did females from mixed-gender classes. UK data noted that girls studying in single-sex schools were more likely to sit for GCSE computer science than those attending co-educational schools (After the reboot: computing education in UK schools, 2017). It was of interest to note that when girls do sit for GSCE computer science they typically tend to get better grades than their male peers, with girls in single sex schools further outperforming their female peers in mixed schools (Kemp et al., 2019). Although one cannot say that peer-support in all-female environments is a direct cause of both a motivation to study and better performance in computer science classes, these findings provide an interesting avenue for further research on the role socialisation and gender.

2.5.5 Structural

A further body of research on gender-imbalance concerns structural factors, which include formal computing education, computer access and computer use (Bartol & Aspray, 2006; Cohoon & Aspray, 2006; Vitores & Gil-Juárez, 2016).

Differences in computer access was once a key area of research on the topic (Bartol & Aspray, 2006; Klawe, 2002; Margolis & Fisher, 2002; Spertus, 1991), and a number of studies have measured the variables of computer usage and access by gender (Desjarlais & Willoughby, 2010; Downes & Looker, 2011; Papastergiou, 2008; Vekiri, 2013; Vekiri & Chronaki, 2008). Arguably this was more likely to have been a key factor in the early days of home-computer access, whereas now girls and boys are more or less equally engaged in their technology usage owing to the growing ubiquity of computers in society and personal devices (Ofcom, 2015). Although some studies support a standpoint of gender equality in terms of technology access (Vekiri, 2013), others have found have found gender differences in terms of frequency and types of computer use (Drabowicz, 2014; Wong, 2016).

Concerning formal education, compulsory school curricula across the globe have been criticised in recent years for not focusing adequately on computing that will provide for society's future needs (Passey, 2017). In the United States, although computer science classes are increasingly being offered, the majority of high schools still do not offer substantial CS courses. Furthermore, schools with large proportions of racial or ethnic groups, minority groups and with students from lower socio economic backgrounds are least likely to offer computer science courses (NCWIT, 2020). Conversely, in the UK females from the poorest areas are more likely to take GCSE level CS than those from the wealthier areas, and CS is more popular among ethnic minority females than white females (Kemp et al., 2019). This is however within a general trend of low female uptake (After the reboot: computing education in UK schools, 2017; Kemp, Wong, & Berry, 2016). It should be also acknowledged that girls' schools are less likely to offer GCSE CS than co-educational schools (Kemp et al., 2016). In Ireland, the formally assessed Leaving Certificate state assessment for Computer Science was launched in 2018 with 40 secondary schools completing the pilot two-year course in 2020, a short coding course for the junior cycle of secondary school was also developed in recent years (NCCA, 2016).

Supplementary to the offerings of formal education, children and adolescents can access computer science activities in the non-formal learning space in the form of clubs and other programmes. While the principal goal of such initiatives has been to attract more students in general to study computing, many programmes focus primarily on broadening the participation of women. Chapter 3 will expand on this aspect of access to computer science as a key element of the research design.

2.5.6 Personal

Finally, there are a number of personal factors believed to be key predictors of girls' intention to pursue computer-related studies and occupations, namely attitudes towards computing and self-efficacy (Barker & Aspray, 2006; Papastergiou, 2008; Sáinz & López-Sáez, 2010; Vitores & Gil-Juárez, 2016). A common theory in studies measuring gender-differences in computer attitudes is that boys have more positive computer attitudes than girls and therefore that they will have higher interest and expectations related to enrolling in computer-related studies Despite some studies that suggest girls may be merely "less interested" in computer science (N. Anderson, Lankshear, Timms, & Courtney, 2008; J. Fisher, Lang, Craig, & Forgasz, 2015), the author argues that personal attitudes are inherently difficult to isolate from social and structural factors. As A. Fisher and Margolis (2002, p. 80) wrote of the attrition rates seen in female CS undergraduates:

"More women than men transfer out of computer science before the third year, expressing a loss of interest. We have found women's exit statements that they are "just not interested" to be a misleading endpoint to a complex process we've seen over time, often involving a drop of confidence preceding a drop in interest. This drop in confidence is usually driven not by low academic performance, but by students comparing themselves unfavourably with others in the light of the dominant image of what constitutes success"

Self-efficacy can be defined in Bandura's (1977) social cognitive theory as an expectation of personal success, or "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives" (Bandura, 1994, p. 71). It is said to be formed through mastery experiences, social modelling, verbal persuasion and psychological responses (Bandura, 1994). Self-efficacy is a cognitive function that scaffolds behaviour, in summary "what people think, believe, and feel affects how they behave" (Bandura, 1986, p. 25). Accordingly, expectancies of success are crucial factors in how educational and career choices are made (Correll, 2004; Eccles, Barber, & Jozefowicz, 1999; Lapan et al., 2000). Historically, girls have shown a tendency to report lower levels of self-efficacy than boys in areas of mathematics and engineering (Beyer et al., 2003; Dickhäuser & Stiensmeier-Pelster, 2003), and measuring self-efficacy in relation to computing abilities, computer self-efficacy (CSE), has become an area of interest in terms of research on gender-imbalance in the field (Cassidy & Eachus, 2002; Kallia & Sentance, 2018; Papastergiou, 2008; Varma, 2010).

Scales have been developed to measure CSE (Eachus & Cassidy, 1996; Ramalingam & Wiedenbeck, 1998) and these tools provide a means to compare differences by gender or other variables. There is some consensus in the literature that girls' lower CSE is correlated with a lack of interest or in computer science careers and study (Meelissen & Drent, 2008; Vitores & Gil-Juárez, 2016), although Kallia and Sentance (2018) argue that such studies are limited. What is interesting to note in such studies is not just how CSE is a predictor of career and educational intent (Papastergiou, 2008), but how the CSE variable may be affected by other factors.

Prior computer experience may seem to be the most logical contributory factor in developing CSE (He & Freeman, 2010; Nelson & Cooper, 1997), yet Vekiri and Chronaki (2008) found that when home computer access, frequency of use, and activity variety were considered together with perceived parental and peer support in regression analysis, they were marginally or unrelated to students' self-efficacy. Parental support, and to a lesser extent peer support emerged as the factors more strongly associated with boys' and girls' computer self-efficacy (Vekiri & Chronaki, 2008). A later study confirmed a hypothesis that student perceptions of teacher expectations and teacher instructional practices and are related to CSE (Vekiri, 2010), furthermore the study found that perceived teacher expectations were more significant for girls' than for boys' self-efficacy. Varma (2010) conducted a study with female CS undergraduates in India and found that both family encouragement and peer-support were linked to self-efficacy, which in turn was a strong influencing factor in the women's decision to study computer science. Crombie, Abarbanel, and Trinneer (2002) found significantly higher levels of confidence in girls who were taught in all-female high school CS classes by comparison to girls in mixed-gender classes. A number of studies claim female students who have had female computer teachers in high school are more likely to study computer science or related third level courses (Beyer, 2008), which may relate to findings from maths and engineering classes that reported higher levels of self-efficacy from girls taught by female teachers (Stout, Dasgupta, Hunsinger, & McManus, 2011). Cheryan et al. (2013) suggest a relationship between computer self-efficacy and perceived similarities to computing role models which affirms the element of social modelling in the development of self-efficacy (Bandura, 1994). Similarly, the Eccles et al. (1999) model of expectancy-value theory suggests that self-efficacy is affected by stereotypes.

In a study of male and female high school students Kallia and Sentance (2018) found that the male participants felt significantly more confident, than females, in areas of computer science and programming but were also more accurate in their self-assessment of performance whereas the girls had a tendency to underestimate their ability. Given that male and female students perform equally well in CS courses (Beyer, 1999; Tam & Bassett, 2006), this suggests how important it is to consider the significance of self-efficacy as a key factor in girls' motivation to pursue computing pathways.

2.5.7 Factors Affecting Gender Imbalance Summary

It is evident that the proposed factors affecting girls' interest are multi-faceted and intersectional. The following section will explore strategies, both theoretical and research based, that may help in addressing gender-imbalance.

2.6 Strategies to Address Gender Imbalance

If the factors that affect female interest and motivation to follow pathways in computer science are complex, so too are the solutions. A well-established criticism of the "leaky pipeline" metaphor is that it frames the problem of the lack of women in IT primarily as a question of how to get more girls and women to supply the pipeline, which usually leads to a primary focus on girls' and women's lack of desire, knowledge, and awareness of science and technological career options (Bartol & Aspray, 2006; Soe & Yakura, 2008; Vitores & Gil-Juárez, 2016). This interpretation alone is insufficient as it ignores the cultural, structural and institutional arrangements that act, obstruct and condition girls' and women's paths into the field (Vitores & Gil-Juárez, 2016). Thus, one should acknowledge that the problem cannot be solved solely by supplying the pipeline with more women, but by changing the institutional and organisational arrangements that constitute the 'pipeline' itself (Vehviläinen & Brunila, 2007; Webster, Castaño, & Palmén, 2011)

Whilst the author agrees with this standpoint, she also must accept the limitations of this study which is focused on providing a pre-college intervention for girls to explore pathways in computer science. Notwithstanding, there are elements of common solutions and strategies that have been proposed across all levels which have in turn influenced the intervention's design. This section will now review these strategies in context.

2.6.1 Role Models

It has been long acknowledged that by providing more female role models the representation of women in computing could be greatly improved (Barker & Cohoon, 2006; Margolis & Fisher, 2002; Spertus, 1991).

The Athena Factor Report stated: "The isolation of women in SET[35] is both a cause and a consequence of the lack of female role models, mentors, and sponsors in SET companies" (Hewlett et al., 2008, p. 14). The report found that gender-based isolation was a key factor in the drop-out of women from professional SET roles, with 40% of technology professionals reporting a lack of female role models and 47% reporting a lack of mentors[36]. The report does not explicitly define the terms "role model" and "mentor", however it is indicated that a mentor is "a senior woman who would offer advice and guidance" and a role model may be more visual and less involved: "just seeing a woman in a top job" (Hewlett et al., 2008, p. 15).

Numerous studies have examined the importance of gender matching in mentoring relationships, in particular for women (Gibson & Cordova, 1999; Lockwood, 2006; Porter & Serra, 2020; Sealy & Singh, 2009), a standpoint that is often held in relation to the various strata of computer science. In academia, Camp (2002) first highlighted the "shrinking pipeline" with a steep drop-off of women from high school all the way to near-extinction at professorship within the computing discipline. Exposure to female role models in STEM disciplines is important for female college students (Amelink & Creamer, 2010; Stout et al., 2011), and relationships between teachers and undergraduate students in the sciences can be particularly significant as observed by Seymour and Hewitt (1997), who concluded that the lack of faculty relationships and mentoring relationships is one of the most common causes of women's drop in confidence and subsequent attrition.

[35] Science, Engineering, Technology
[36] The terms role model and mentor can mean different things across the relevant literature, but the author would concur that the term "mentor" implies a more invested and formal role than "role model".

Both Carnegie Mellon University and Harvey Mudd College established mentoring practices within their computer science departments, as part of a suite of strategies to successfully recruit and retain female students (Alvarado et al., 2012; Margolis & Fisher, 2002). More recently, Rutgers University developed a "Computer Science Living-Learning Community" where a cohort of first year women intending to major in computer science effectively live together in a college residence community supported by various academic, graduate and peer mentors (Wright, Nadler, Nguyen, Gomez, & Wright, 2019).

Likewise, enlisting female mentors and role-models is a common strategy taken by stakeholders to inspire the interest of adolescent and younger girls (G. Lawlor et al., 2020). Career-talks or panels are a familiar short-term activity in which role-models are made visible to students (Frieze, 2005; Hunter & Boersen, 2017; Maciel, Bim, & da Silva Figueiredo, 2018), and many outreach programmes use female mentors or facilitators in delivering their workshop content (Almjeld, 2019; Gannod, Burge, McIe, Doyle, & Davis, 2014; Heo & Myrick, 2009). Other initiatives use role-models in more abstract ways, for example one approach saw a booklet on the contribution of women to computer science distributed to girls in UK secondary schools (Black, Curzon, Myketiak, & McOwan, 2011). As within other academic and professional fields, the role of women as historical protagonists has been largely neglected in the history of computing (Vitores & Gil-Juárez, 2016). By promoting works that highlight and celebrate the contributions of notable women: (Abbate, 2012; Gürer & Camp, 2002; Shetterly, 2017), the common narrative of computing as a male field can be challenged whilst making eminent role models more visible (Vitores & Gil-Juárez, 2016).

A more in-depth analysis of the outreach space including the use of female mentors and role-models is given in section Chapter 3.

2.6.2 All-Female Environments

Section 2.5.6 reported on the potential benefits of all-female environments in terms of improving computer self-efficacy and future motivation to study computer science (Crombie et al., 2002; Kemp, Wong, & Berry, 2019). Despite substantial debate from both sides, the proponents of single-sex education believe that separating boys and girls, by classrooms or schools, increases students' achievement and academic interest (Pahlke, Hyde, & Allison, 2014). One argument in favour of gender-segregation is that in co-educational classrooms, boys have a tendency to seek out and monopolise teachers' attention, particularly in mathematics and science, thus decreasing girls' interest in those fields (Lee, Marks, & Byrd, 1994; Sadker & Zittleman, 2009).

Harvey Mudd College (HMC) and Carnegie Mellon University did not go so far as to implement gender-segregated classes, however both colleges did recognise the issue of male dominance: "In all introductory CS courses, instructors deliberately discourage the most experienced students from intimidating others in class by showing off their knowledge. Eliminating this "macho" effect has significantly improved the culture in all CS courses at HMC, resulting in a more supportive learning environment for all" (Klawe, 2013, p. 57); "We also need to find ways to reduce the occurrence and remove the sting of comments such as, "*You are only here because you are a girl*." Students must be educated about admissions policies that show that this is not so, and also understand that the institution considers taunting such as this to be unfriendly and hostile to students' learning environment" (A. Fisher & Margolis, 2002, p. 81).

Both colleges also organised events, activities and support groups with a view to fostering a community to support the women's academic development (Alvarado et al., 2012; Frieze & Blum, 2002), while the Computer Science Living-Learning Community (LLC) at Rutgers provided a unique opportunity for first-year students to live in an all-female computing environment. Apart from the residential and mentoring element, the LLC programme also included a variety of activities to support the participants' development as CS majors (Wright et al., 2019). There were some mixed results found in a comparative evaluation of the LCC; a higher proportion of LLC participants stayed in their CS major over time (88%) than the comparison group (53%), LLC participants reported more involvement in computing related activities and also better mentoring and peer support. However, both the LCC and comparative group reported weaker computing self-efficacy to the same degree over time, stronger beliefs that computing ability is inborn and stronger interest in non-computing careers (Wright et al., 2019).

Many computing outreach programmes are exclusively for girls (Decker et al., 2016; Kamberi, 2017; G. Lawlor et al., 2020). Other programmes with a view to encouraging more participation in general have dedicated all-female factions, for example CoderDojo Girls (McHale, 2019). A number of programmes go further, by limiting membership to the more marginalised girls of colour (Hulick, 2017; Madrigal, Yamaguchi, Hall, & Burge, 2020; McFarlane & Redmiles, 2020). Some programmes clearly state how their programmes are adapted or designed for an all-female audience (Kelleher & Pausch, 2006; Starrett, Doman, Garrison, & Sleigh, 2015; Sullivan et al., 2015), generally by contextualising programming and computational thinking through purportedly gender-relevant means (storytelling, textiles, community projects etc.).

It is not difficult to justify a case for providing all-female environments such as these, particularly in the non-formal educational setting where girls and young women elect to participate, as Almjeld (2019) writes: "Girls' technology camps are wonderful spaces to build girl-centric communities where risk taking, failure, and success are equally celebrated". Nonetheless, others question the assumption that an all-girl model is the most effective approach for such interventions (Kamberi, 2017), and further research is needed in the area.

2.6.3 Pedagogical Practices

Literature would suggest that much of the lack of success in capturing students' interest in STEM fields has to do with the way that science is taught in institutions of higher education (Astin & Astin, 1992; Rosser, 1990; Tobias & Lin, 1991). As noted in other STEM disciplines, computer science teachers have a tendency towards an authoritarian, lecture-dependent style and are often criticised as being less supportive relative to teachers in other fields (Beyer, 2014).

The American Association of University Women once strongly criticised computer science courses as "bastions of poor pedagogy", reporting complaints that courses were poorly taught, or structured to "weed out" weak students (AAWU, 2000, p. 41). Salminen-Karlsson (2009) suggested that traditional computer education failed to accommodate students (female and male) with other learning preferences than those of the traditionally male student:

"The main differences between women and men learners are found to be in the areas of self-confidence as a learner, cooperation with other students, relationship to teacher authority, risk taking, and the connection of academic content to everyday life."

(Salminen-Karlsson, 2009, p. 152)

At Carnegie Mellon University (CMU) and Harvey Mudd College (HMC), major changes were made to overhaul the traditional teaching practices of their CS courses. Approaches taken by CMU included; situating technology in realistic settings; designing curricula to exploit the connections between computer science and other disciplines; providing diverse problems and teaching methods that appeal to a broad variety of preferences and styles (A. Fisher & Margolis, 2002). Similarly, HMC focused on creating an innovative introductory course that emphasised problem solving using computational approaches. This was designed to give first-year students a broader view of CS, demonstrate the breadth of the discipline, and quickly immerse students in various core topics and activities (Klawe, 2013).

A link between confidence (or lack thereof) and prior programming experience in undergraduates had been long been identified (Margolis & Fisher, 2002; Spertus, 1991). Accordingly, CMU designed computer science curricula that allowed students with varying levels of experience to enter courses at multiple points of entry with appropriate prerequisites (A. Fisher & Margolis, 2002). Similarly, HMC made the deliberate decision to stream their classes according to prior programming experience in an effort to combat the trend of women feeling intimidated by comparison to the more experienced men (Klawe, 2013). Such measures are indisputably progressive, by comparison to the aforementioned perception of CS courses "weeding out" less seasoned students (AAWU, 2000).

Akin to third-level education, research has indicated that high-school CS education tends to be teacher-centred and decontextualized, providing students with few opportunities for collaboration and engagement in challenging, creative, and personally meaningful tasks (Clarke & Teague, 1996; Goode, Estrella, & Margolis, 2006; Vekiri, 2010). Vekiri (2010) suggests that this traditional approach is likely to be more detrimental to the motivation of girls who prefer a more collaborative and contextualised approach. If teachers adopted a more student-centred and gender-inclusive approach taking into account these preferences, more girls would be interested (Crombie et al., 2002; Goode et al., 2006; Vekiri, 2010).

The role of pedagogy in non-formal CS education is relatively underexplored (Alsheaibi, Strong, & Millwood, 2018; G. Lawlor et al., 2020; Sullivan et al., 2015). This is not to say that outreach programmes do not engage in pedagogical practices that are preferential to girls and young women, in fact many programmes share a lot by their teaching approach (Decker et al., 2016; G. Lawlor et al., 2020). A more collaborative, project-based and creative approach may just be inherent to learning that takes place outside of the formal curriculum but within a semi-structured environment (W. Patrick, 2010), with or without conscious design. A more detailed analysis of pedagogical practices within the outreach space is offered in section Chapter 3.

2.6.4 Access and Relevance

Opportunities to study computer science in adolescence are a prime influence on women's future interest in the subject (Hinckle et al., 2020; Zarrett, Malanchuk, Davis-Kean, & Eccles, 2006), however access to second level or high-school CS education varies greatly across the globe (Hubwieser et al., 2015). Lack of access to formal high-school CS instruction as a structural barrier to girls was discussed in section 2.5.5.

Apart from formal classes, schools should consider other ways to effectively market computer science pathways to girls (Black et al., 2011; Sáinz, Pálmen, & García-Cuesta, 2012; Stockdale & Keane, 2016; J. Wang, Hong, Ravitz, & Ivory, 2015). Short events and activities that promote a positive perception of computer science through career talks and other strategies are cost-effective and simple (Craig, Coldwell-Neilson, & Beekhuyzen, 2013; Frieze, 2005; Mason, Cooper, & Comber, 2011; Thangarajah, Keshavjee, & Smith, 2014; C. Q. Wang, Tang, Zhang, & Cukierman, 2012). Many interventions report that women who are invited to speak to girls in schools do serve to encourage greater interest in computing (Klawe, Whitney, & Simard, 2009), however there is little empirical data available on the longer term impact of such activities (J. Fisher et al., 2015).

As many countries move towards a "computing for all" mind-set, the delivery of learning continues to evolve and take many forms including the boomlet of non-formal educational opportunities such as summer camps, after school clubs and other dedicated organisations and projects (Decker et al., 2016; McGill, Decker, & Abbott, 2018). This research concerns the design and evaluation of one such initiative "CodePlus", based on analysis of the outreach space and the many factors considered to impact girls' motivation and interest in the field. Chapter 3 will return to this topic with a systematic literature review that reports on the design, objectives and findings of such programmes that were available.

2.7 Chapter Summary

This chapter began with an outline of the literature review process, followed by a historical account of women in computing from the time of pre-electronic machines through the 20th century where a steep-decline in women's participation occurred in the later decades. Background literature was also reviewed on the subject of the gender-digital divide, and both the subsequent economic and societal ramifications of women's underrepresentation as the fourth industrial revolution approaches and the ubiquitous nature of computers in society continues to accelerate.

Major themes and factors considered by the literature in relation to women's lack of participation and drop-out in the field, characterised as "the leaky pipeline", were discussed including biological, societal, structural and personal. Analysis of theoretical and empirical data suggest that many such factors are interlinked and complex, often leading to more questions as opposed to simple explanations for the phenomenon under investigation.

Across various strata of professional and education levels, strategies and approaches taken by various stakeholders to address gender-imbalance were considered. These included the importance of providing visible female role models and mentors, exploring support in all-female environments, access to computing education and the potential of pedagogical practices to motivate girls and women's interest in the field. The area of outreach in the non-formal education space as an early intervention strategy was discussed in brief, to be more thoroughly explored in the following chapter as a meta-analysis of empirical research data available.

Analysis of both the theoretical and research based literature in Chapters 2 and 3 informed the justification for and design of the research study under investigation, which will be discussed in the Design Chapter 4.

3 Meta-Analysis of All-Female CS Outreach Programme Studies

3.1 Introduction

In this chapter, the author has taken the free-form question "What are the characteristics of peer-reviewed research conducted on all-female adolescent and pre-adolescent computing outreach activities?" as a basis for a systematic literature review on the topic. This approach is based on that of a meta-analysis study (Decker et al., 2016), which examined the general area of CS outreach, including mixed gender studies, over the period 2009-2015. In keeping with the focus of this dissertation the analysis focuses exclusively on all-female, single sex programmes in the non-formal education space, for participants in the 10 to 18-year age interval.

The sub-questions that guided the analysis were as follows:

(1) What attributes, practices and culture do adolescent and pre-adolescent all-female CS outreach programmes share?

(2) What are the aims and objectives set by the programmes?

(3) What type of data has been collected by such programmes?

(4) What findings are reported by the programmes?

The author undertook a systematic literature review to identify, evaluate, select, and synthesize results of peer-reviewed, published research involving all-female computing outreach programmes. In keeping with the approach of Decker, McGill and Settle (2016), the analysis followed the framework developed by Khan, Kunz, Kleijnen, and Antes (2003). This framework has five foundational steps: frame the question, identify relevant work, assess the quality of the studies, summarize the evidence, and interpret the findings. Section 3.2 describes the first three steps in detail, while the evidence summary and interpretation of the findings is presented in Subsections 3.3 and 3.4.

3.2 Methodology

3.2.1 Framing the Question

To begin the process of the literature review, a broad, free form question was formulated to guide the initial steps in identifying relevant work. In consideration of the research question, the following overarching characteristics were identified:

1. Populations studied: Participants in all-female computing outreach programmes.
2. Interventions: Programmes that exposed students to computing concepts or exposed students to career talks from female CS role models, or both.
3. Programme objectives: Improving self-efficacy, attitudes, skills, knowledge, or dispositions towards CS.
4. Pedagogical underpinning: Use of paired or group work, other specified pedagogical practices (or unspecified).
5. Study designs: Quantitative, qualitative, or mixed methods studies. Short term and longitudinal studies.
6. Programme Outcomes: Effects of the programme on participants' self-efficacy, attitudes, skills, knowledge, or dispositions.

3.2.2 Parameters of the review

The following databases were considered as reputable sources for formal, blind, peer-reviewed computing education research: ABI Inform, ACM Digital Library, De Gruyter eBooks, IEEE, JSTOR, Science Direct, Springer Link, Taylor and Francis and Wiley Online. The inclusion of these databases was based on the approach of (Decker et al., 2016) and the guidance of the college Computer Science subject librarian. Using this as a starting point for finding relevant literature, the author further refined the search to publications emphasizing education and computing, which led to identifying the following peer-reviewed journals and conference proceedings:

- ACM Transactions on Computing Education (TOCE)
- Frontiers in Education (FIE)
- Innovation and Technology in Computer Science Education (ITiCSE)
- International Computing Education Research Workshop (ICER)
- ACM SIGCSE Technical Symposium on Computer Science Education (SIGCSE)
- Springer Journal of Computers in Education
- Taylor & Francis' Computer Science Education (CSE)

The search terms used were “Outreach” AND "Computer Science" AND “Girl/girls”. Synonyms used were:

Outreach: “Non-formal Education”, “Voluntary”, “Extra-curricular”, “Camp”, “After-school”, “Outside School”, “Summer Camp”, “Programme”.

Computer Science: “CS”, “Computing”, “Technology”, “IT/Information Technology” “Programming”, “Coding”.

Girl/Girls: “Adolescent Female/s”, “Adolescent Women”, “Female Youth”, “Teen Girl/s”, “Young Women”.

This resulted in 718 citations that were reviewed for relevance. An article was determined to be relevant if, upon review it had a title and abstract associated with all-female adolescent or pre-adolescent outreach with one or more of the criteria listed in 3.2.1. 673 papers did not fit the criteria and were deemed irrelevant for the purposes of this review. This resulted in 45 articles to undergo a more thorough review and they are listed in Appendix A. To evaluate these, the overarching characteristics were considered and categories were created for logging the data.

Parameters on the year of publications were not set deliberately. This strategy was to ascertain the history of publications related to the all-female outreach activities and to examine possible trends in the concentration of publications over time. Figure 3 below provides summary statistics of the volume of publications observed in the 45 papers analysed from 1996-2020 inclusive:

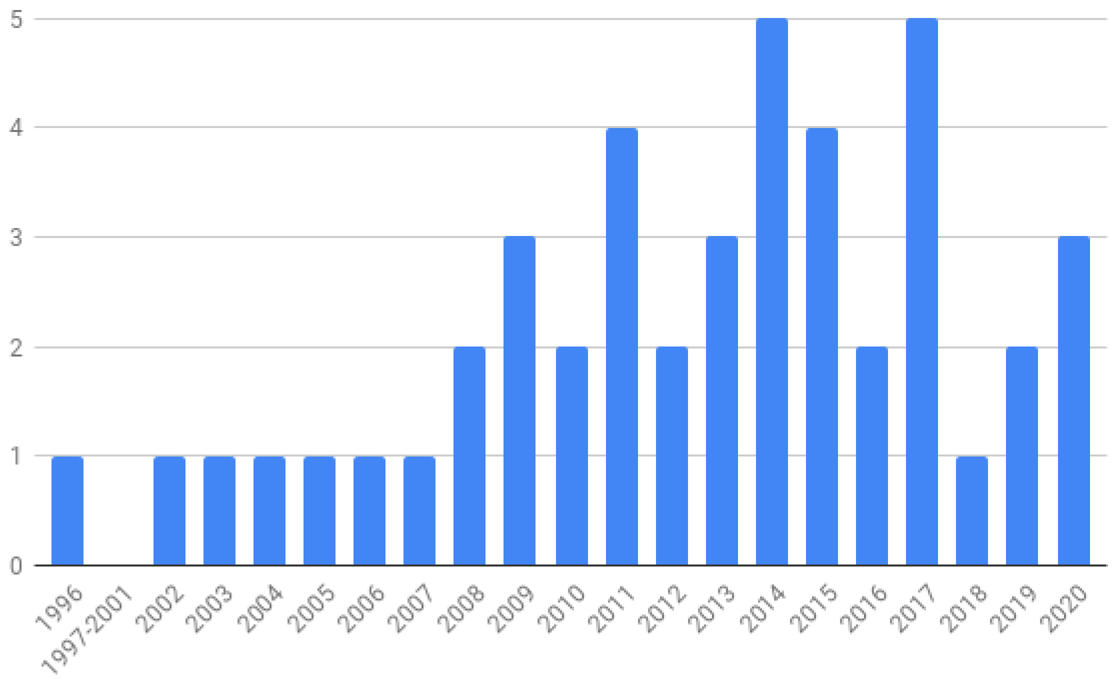

Figure 3: Summary of publications by year

Table 3 below outlines the key characteristics informing a design matrix used in organising the data collected from the review of the papers (n=45):

Characteristic	**Examples**
Age group	Grades or ages of students
Number of participants	N= x
Length of Intervention	1 week, 1 day, longer term
Research Design	Short term, longitudinal or both. Quantitative, qualitative or mixed methods. Type of data collected (participants' self-efficacy, attitudes, skills, knowledge, or dispositions)
Programme aims and objectives	Intended outcomes of interventions
Location of study	Geographical location
Setting of intervention	College campus, after school clubs etc.
Pedagogical approach	Specified or unspecified. Group and pair work, project based learning etc.
Use of role models or mentoring	Explicit reference to a role model and a career talks element or both.
Findings	Results of studies

Table 3: Characteristics defined for analysing relevant work

3.3 Results

The next step in the review process was to summarise the papers (n=45). This included information on geographical location of studies, the publishing venue, the length of interventions, the age profile of participants, the number of participants in each study, and the research designs employed by each study.

3.3.1 Programme locations and publication venues

Figure 4 provides an overview of the papers by geographical location while Table 4 provides an analysis of the venues where the studies were carried out. The majority of papers were from the US (66%), seconded by Canada and Australia[37] (12% each). Two studies were German (4%) and Brazil, Ireland, Saudi Arabia and the UK each contributed 1 paper.

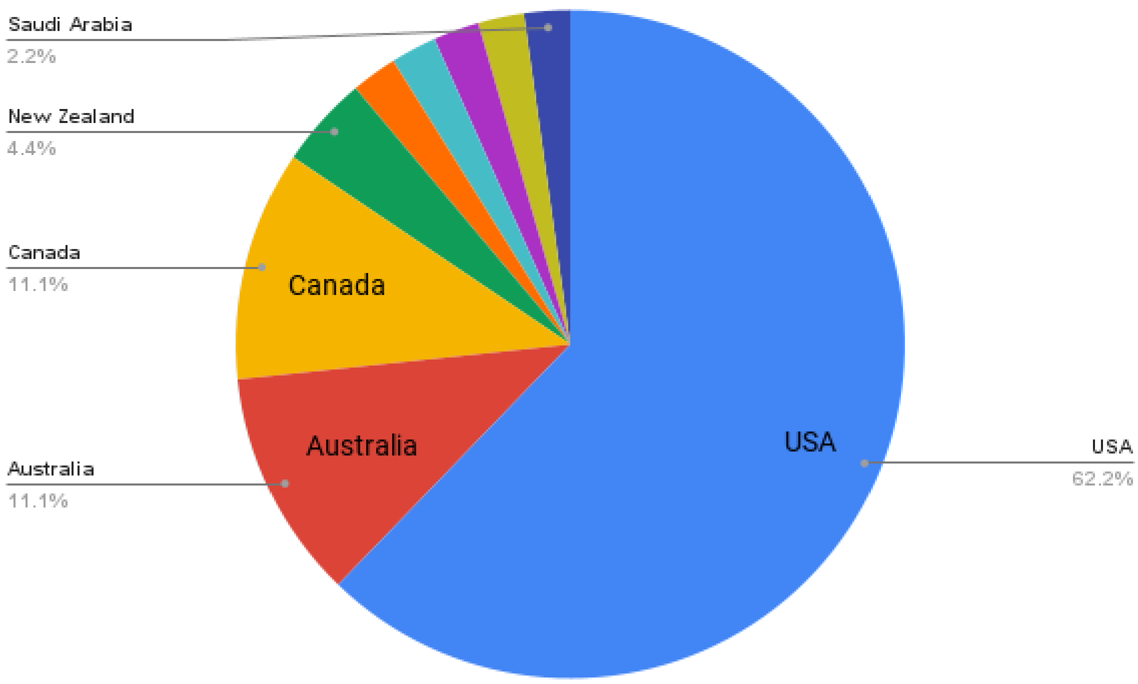

Figure 4: Countries where studies took place

[37] Three of the five Australian papers reviewed are based on the same study of the "Digital Divas programme" (Craig, Fisher, Forgasz, & Lang, 2011; Lang, Craig, Fisher, & Forgasz, 2010; Lang, Fisher, Craig, & Forgasz, 2015)

Publication	Articles found
ACM TOCE	2
ACM Inroads	2
ACM SIGCSE	9
ACM ITiCSE	7
ACM Technical Symposium on CS Education	10
IEEE	9
CSE	3
Science Direct Computers and Education	3
Total	**45**

Table 4: Papers by publication venue

3.3.2 Summary of programme numbers

The number of participants as reported by the interventions ranged from 10 to 6100. Figure 5 provides a breakdown of the number of participants in each study. The largest proportion of studies had small sample sizes with 19 or less participants. There were five programmes that did not clearly indicate the number of participants.

Figure 6 shows the breakdown of the length of the interventions which varied from 1 day to longer than 10 weeks. Several studies were difficult to categorise in this way as they involved multiple-approaches and interventions of varying length (Kelleher & Pausch, 2006; Maciel, Bim, & da Silva Figueiredo, 2018; Pivkina, Pontelli, Jensen, & Haebe, 2009), and in such cases multiple periods of engagement were recorded. It is also important to note these statistics do not take into account the length of interventions by hour. For example, a 4-week programme may be an hour after school each week in some cases, so a one-day intervention of 6 hours may in fact have more contact time in practice. The majority of interventions (n=14) were one day long, followed by one-week interventions (n=13) that typically followed the format of an intensive multi-day or residential camp model.

Figure 7 shows the breakdown of the age ranges of participants and ranged from 10-18 years. In a number of articles, grade level was given in place of age. In these cases, the grades were converted the to the typical age range of students in the grade or grade range as appropriate to the relevant education system. It should be noted that several studies had an age profile of participants that spanned across more than one of the ranges. In these cases all relevant ranges mentioned in the study were recorded. The highest concentration of studies involved the 13-15 age interval (n=25), followed by the 16-18 (n=15). There were a small number of studies (2) that did not specify the grades or age ranges of participants.

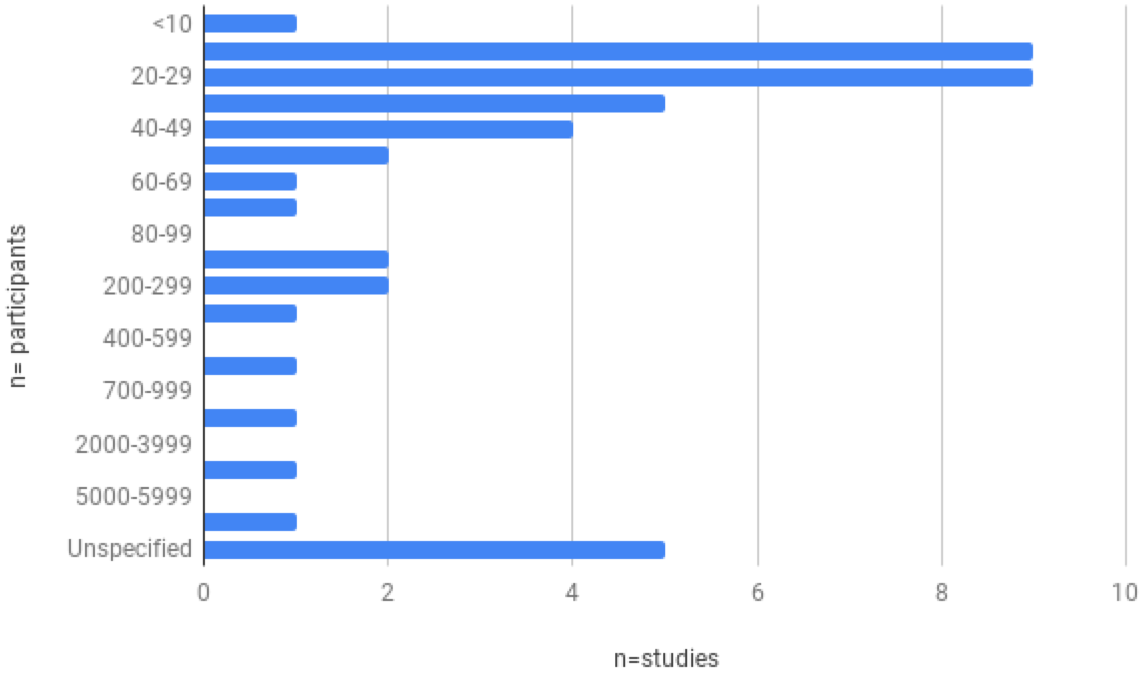

Figure 5: Breakdown of numbers of participants in each study

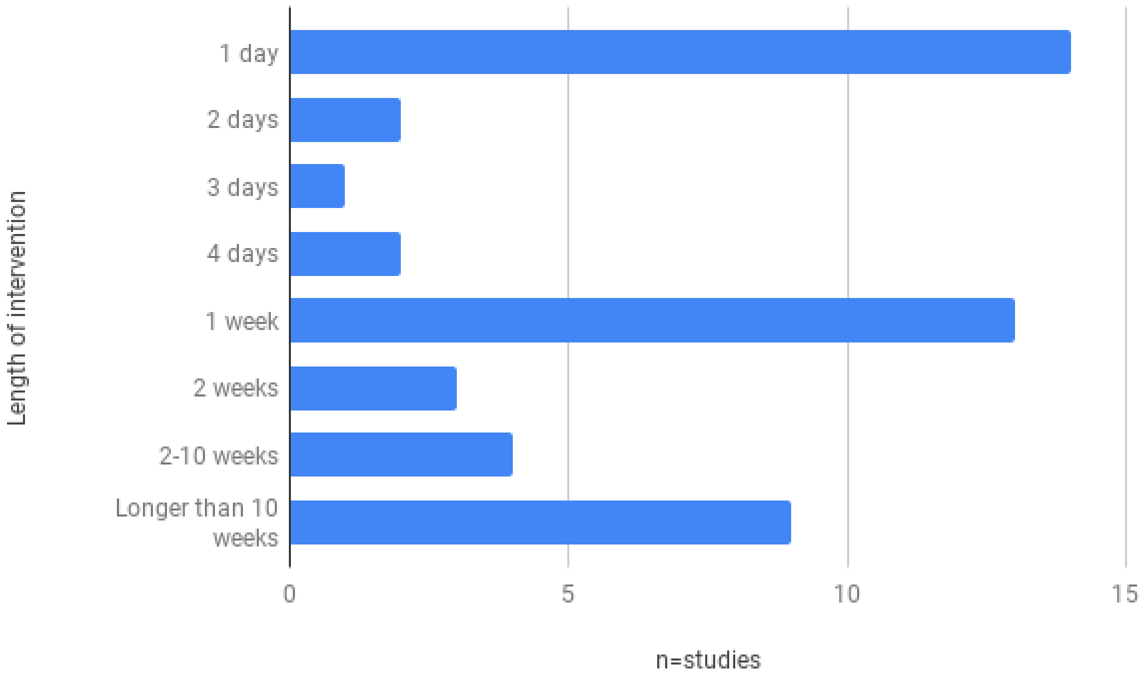

Figure 6: Breakdown of length of interventions

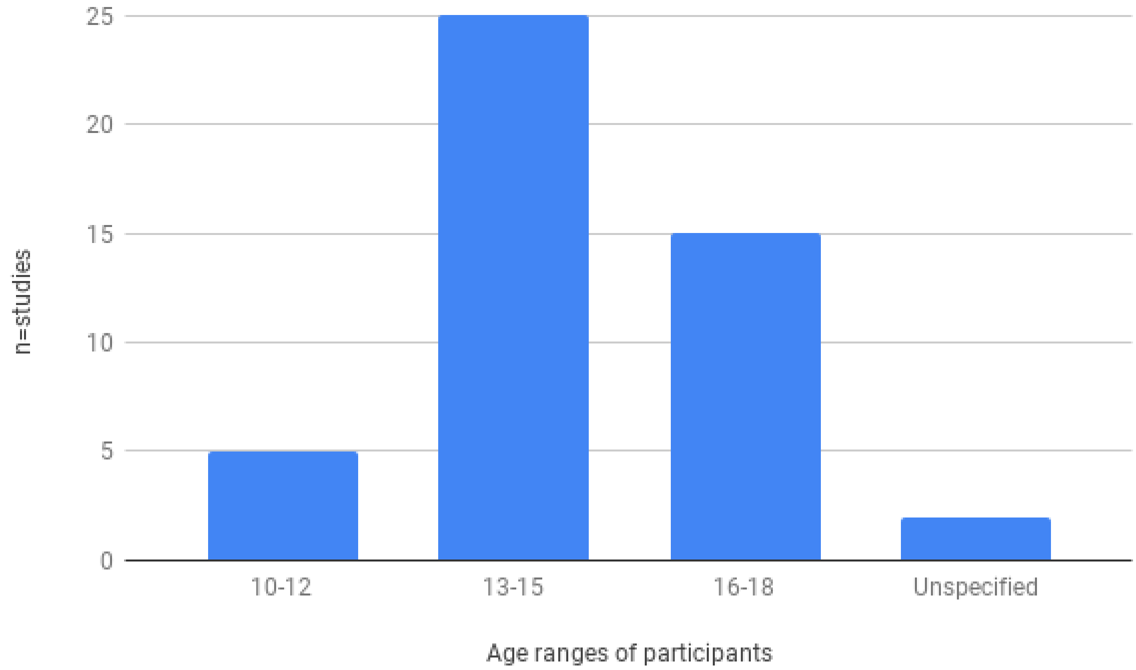

Figure 7: Breakdown of age ranges of participants

3.3.3 Programme setting, use of role models and pedagogy

The setting of the programmes was recorded and is presented in Figure 8. A small number of programmes took place in multiple settings, e.g. a campus workshop and a school talk and in these cases each individual setting was noted. Overwhelmingly activities took place on college or university campuses (29 studies), followed by 11 programmes run in schools – these can be considered as non-formal learning as the activities were voluntary after-school, lunchtime-clubs, or electives outside of the students' formal education curriculum. Two studies took place in girl scout groups or youth clubs and another two took place in what were described as national or regional "learning centres". One study took place at a girls' summer camp. There was one study that took place within a tech company and finally four studies in which it was not possible to identify a setting.

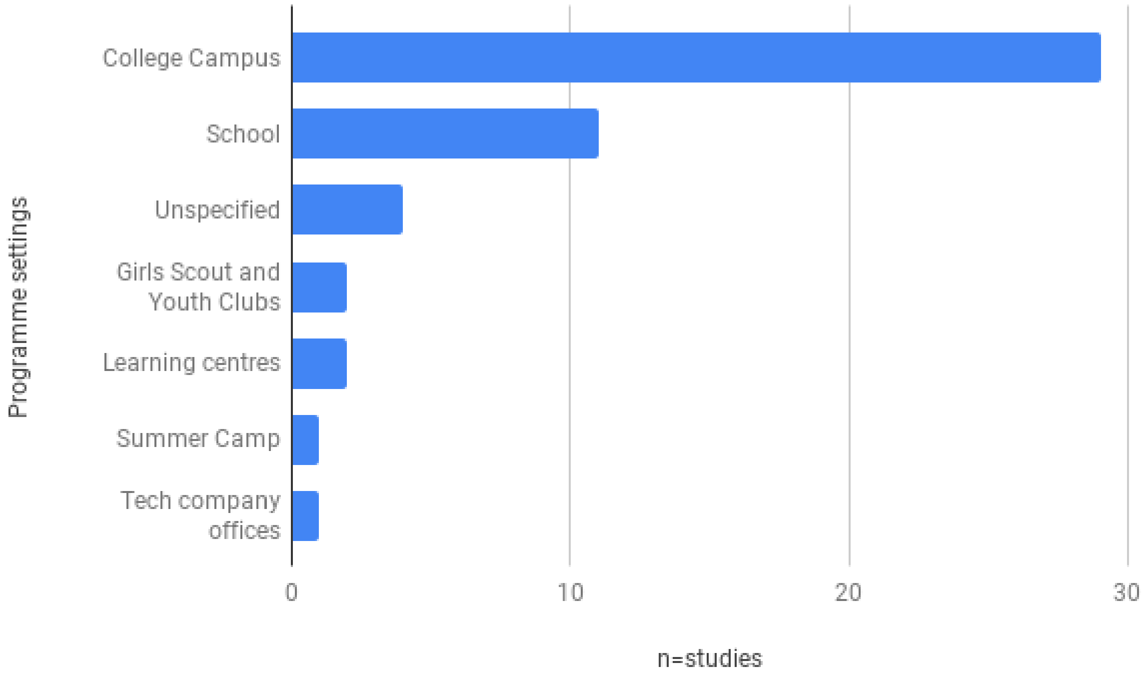

Figure 8: Summary of programme settings

Initial reading of the literature indicated that a common strategy used in outreach programmes was to enlist female role models, either working or studying in the field of computer science, in an effort to engage and inspire the participants. As reported in the studies, role models or mentors had two main functions, primarily they offered instruction or teaching support in workshops, secondly many studies adopted programmes in which women would talk to the participants about their career and college experience. Some studies adopted both approaches. Accordingly, four distinct categories were established for analysis purposes: facilitators, career speakers, use of both, and use of neither or unspecified – see Figure 9.

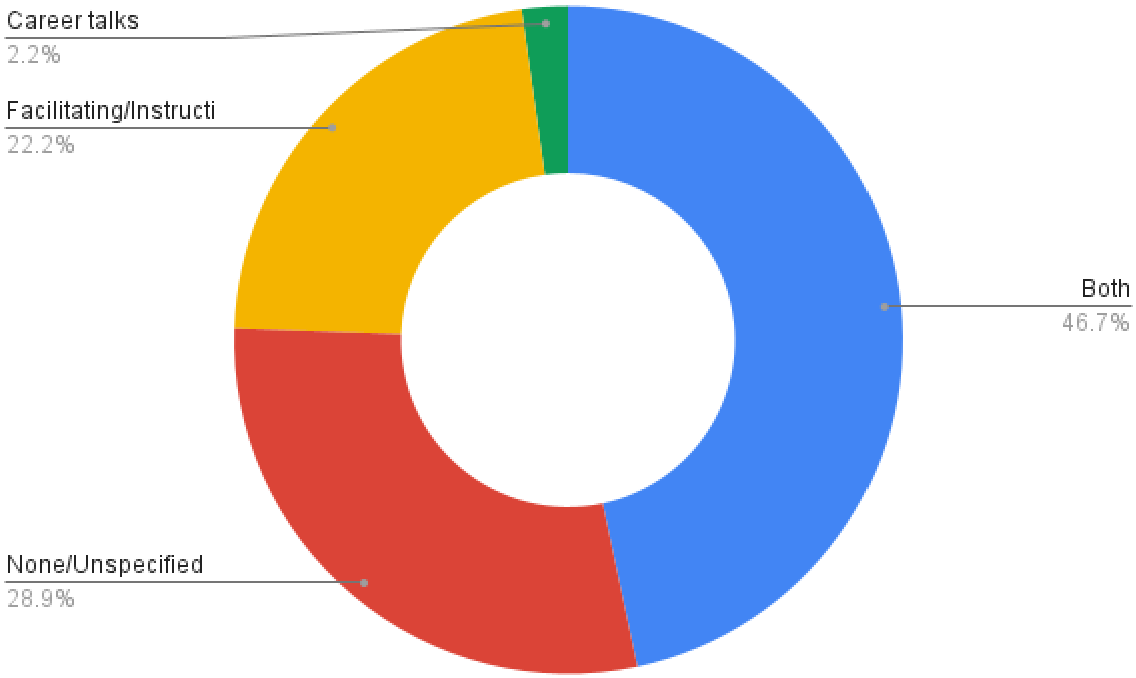

Figure 9: Use of role models and mentors in studies

Almost three quarters of the studies used female role models as facilitators or instructors and to deliver career talks. Ten studies indicated their use of female facilitators but not career talks in their programmes. Just one study used career talks only. It was interesting to note that thirteen studies did not indicate whether they were using female role models as instructors or speakers within their programmes. It may be the case that the relevant researchers did not consider this an important design element to report. Furthermore, it is also important to note that in the instances in which studies did report on the use of role models, the detail given to that aspect of the design varied greatly within papers. The discussion section of this chapter will explore in greater detail the element of female role models and it's perceived importance in girls' outreach programmes.

There is strong criticism of the prevalent pedagogy in formal CS settings and it is suggested that an authoritarian, didactic style of teaching is a deterrent to female students (Waite, 2017) . In light of this to this, the author sought to explore the role of pedagogy in the non-formal outreach space. A broad definition of "pedagogy" is taken and studies were examined for a clear statement of a teaching style or method – see Figure 10:

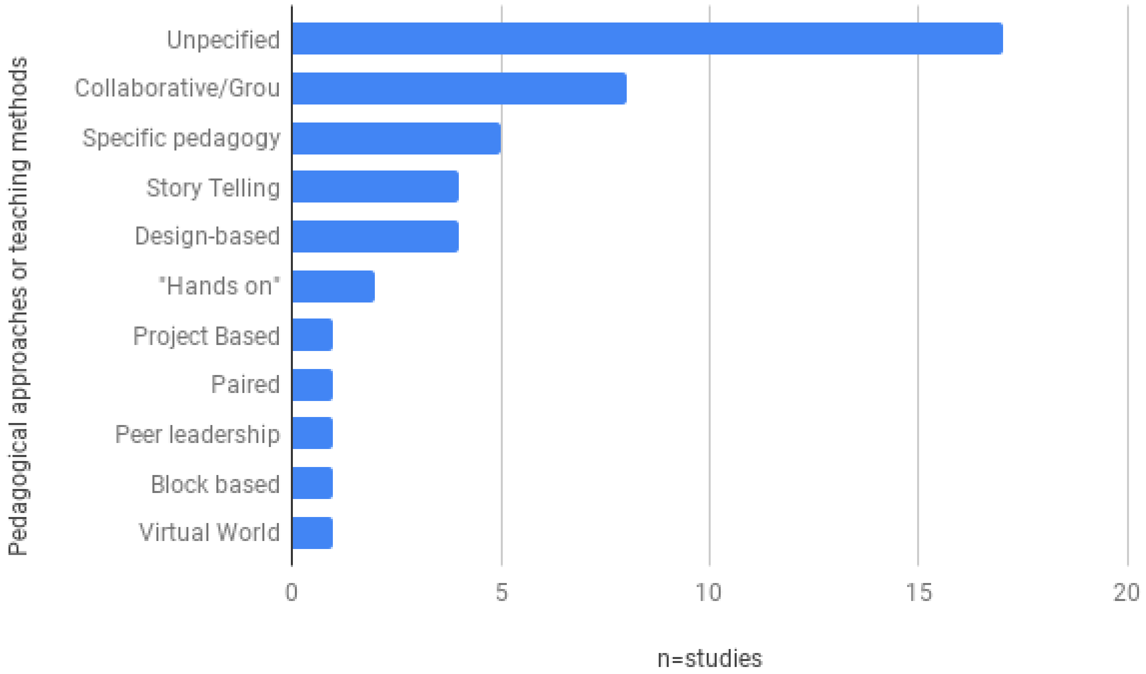

Figure 10: Pedagogical approaches or teaching methods indicated by studies

Seventeen of the studies reviewed did not indicate a specific approach to teaching. Eight studies reported on the use of either a collaborative, group or team teaching approach. Five studies named a distinctive pedagogy; Constructivism (Denner, Werner, & Ortiz, 2012) , "Piagetian and Vygotskian perspectives on learning"(Marcu et al., 2010), The Bridge21 model of teaching and learning was employed in the context of an all-female outreach programme (Sullivan et al., 2015), a model that is used in a broad range of educational contexts. "responsive pedagogical framework" (Scott, McAlear, Martin, & Koshy, 2017) and a "culturally responsive" responsive approach (Madrigal et al., 2020). Four studies adopted an approach of teaching programming through storytelling while another four studies indicated design based or design thinking used in their programmes. Two programmes mentioned a broad "hands-on approach" to teaching and learning with one programme describing their approach as "project based". One programme consciously used a virtual word application (Hulsey, Pence, & Hodges, 2014) , while another used block based programming languages (Seraj, Katterfeldt, Bub, Autexier, & Drechsler, 2019). While a tool or programming language is not a pedagogy in itself both studies gave a detailed rationale for their choice of technology in relation to desired learning outcomes and methods for learning. One study mentioned the use of paired-programming while another mentioned an emphasis on a peer leadership methodology embedded within their programme.

3.3.4 Methodologies

Figure 11 documents the research methodologies used in the studies examined. Most were mixed methods in nature (67%). There were 5 quantitative (11%) and 4 qualitative (9%) studies represented. The author was unable to identify a methodology in six cases.

All articles reviewed reported that they engaged in short-term[38] evaluation. Eight studies[39] reported on engaging in a longitudinal element to the research with the range being between one and three years following participation in the study.

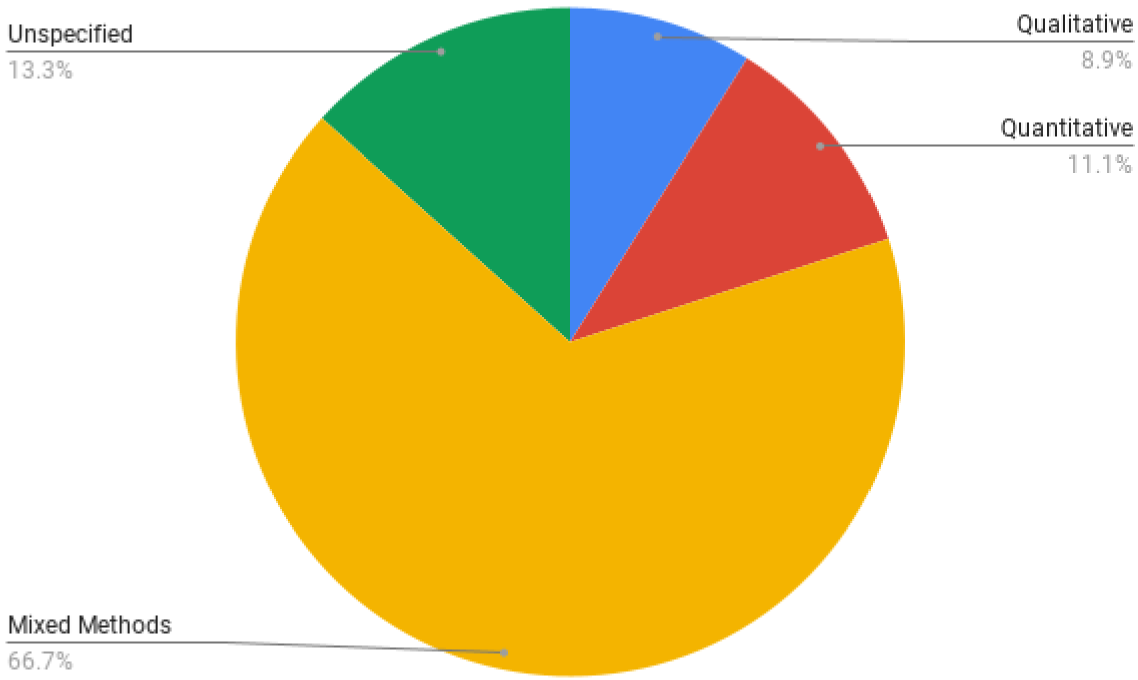

Figure 11: Categories of research methodologies used in studies

[38] Short-term is defined by the researcher as data collected during or immediately following the intervention

[39] Three of these articles concerned the same Australian study with data collected over a number of years

3.4 Assessing Impact

Methods of assessing the impact of programmes varied across the studies. The author approached collecting this data by reading all papers to establish:

1. The goals, aims or objectives set out by the studies
2. Details on the type of data collected in the studies
3. The findings reported in each of the studies

3.4.1 Programme Objectives

All of the studies stated an aim, goal, objective or focus (or multiple aims) for their programme. Unsurprisingly there were a number of easily distinguished goals shared between programmes. The broad objective of "sparking interest in CS", or, "encouraging interest in CS" dominated in 21 of the 45 studies. Fifteen studies alluded to the goal of attracting more girls to the field of CS or more specifically guiding more girls towards choosing to study a CS related course in college. Twelve studies mention improving perceptions of CS and addressing negatively held stereotypes. Eleven studies mention an aim to improve either programming or CS skills and knowledge. Nine aimed to either increase awareness of careers in CS or to demonstrate the ubiquity of computers in society and the subsequent demand for CS skills. Six studies aimed to explore the effects of specific pedagogies or technologies, while another six mentioned improving the participants' computer self-efficacy or confidence with computing and programming as an objective. Four studies stated an aim to present relevant female role models to the participants. One study mentioned building leadership skills with participants as the primary goal of the programme: "the current tech camp focuses more on leadership skills increasing self-esteem, building safe spaces to fail, and encouraging dissent—and less on technological know-how" (Almjeld, 2019).

3.4.2 Types of Data Collected

A summary of the types of data collected in the studies examined is presented in Table 5.

Participants self-reported interest in future study or pursuing study or a career in computing dominated the results with 14 studies (31%) collecting this type of data. Another relatively popular element was attitudes towards computing n=12 (27%). It is important to note that this category tended to broadly cover a number of attitudinal aspects which varied by study, but as the term "attitudes towards computing" was used universally by the group of studies, it is included in the table. Ten studies reported on measuring perceptions and stereotypes of computer science, ten studies included an evaluation of the workshop itself and nine programmes measured the participants programming or computing skills and knowledge. Eight programmes measured the participants' computer self-efficacy, five programmes measured a broad general interest or a desire to learn more following participation in the study and two studies examined the participants' views on the use of an all-female environment. One study examined the participants' final choice of college course. One study explored other influences outside of programme on girls' predisposition to careers and study in CS. Nine studies observed gave very limited or no detail on types of data collected.

Type of Data Collected	**Number and percentage of studies that collected data type**
Self-reported interest in future study of pursuing study or a career in computing	14 (31%)
Attitudes towards computing	12 (27%)
Perceptions and stereotypes of computer science	10 (22%)
Evaluation of the programme, camp or workshop itself	10 (22%)
Programming and computing skills, ability or knowledge	9 (20%)
Self-efficacy or self-confidence	8 (18%)
Sparking general interest or desire to learn more	5 (11%)
Participants views on the use of an all-female environment	2 (4%)
Choice of actual college course (longitudinal)	1 (2%)
Exploring other influences outside of programme on girls likelihood to choose CS	1 (2%)
Little or no detail given by programme on types of data collected	9 (20%)

Table 5: Summary of types of data collected by studies

3.5 Programme Findings

The final step in summarising the methods by which studies were assessed was to categorise the findings from each study under review. This process was similar to the analysis of aims and data collection types in that the author read each paper systematically to ascertain the findings of the study. Following an initial reading of all papers for context, the author identified three distinctive categories of findings in the studies: participants' computer self-efficacy, participants' perceptions of computing, and participants' likelihood to study computer science in the future.

It is important to note that the instruments, method, and the rigour with which data was analysed and reported varied considerably across the range of studies reviewed. Taking this challenge of variance into account, the author contends that all papers analysed have been peer-reviewed and accepted for publication across a range of academic journals, proceedings and other papers. To that end, the findings presented are accepted by the author as those reported within the studies. Table 7 provides a summary of the reported effects with regard to the three broad categories as identified:

Category	**Positive Effect**	**Negative effect**	**No change or mixed results**	**Unspecified**
Self-efficacy	18	0	8	19
Perceptions of Computer Science	30	0	2	13
Future CS Plans	16	1	14	14

Table 6: Summary of findings by category

3.5.1 Perceptions of Computer Science

As reported in the studies reviewed, the category that yielded the most positive results was "perceptions of computer science" with 30 studies (66%) reporting positive findings. "Overwhelmingly (93%), participants in these studies indicated that the programme had changed their perceptions of computer science – and for the better" (Jung & Apedoe, 2013). "An average of 75% of the participants described a positive change in their attitude towards computers and careers with computers as a result of the conference." (Thangarajah et al., 2014), "after the event, all except one girl reported positive feelings about the IT industry and its career opportunities – they were excited, buzzy, and enthusiastic" (Hunter & Boersen, 2017). Two studies reported no change or mixed results and 13 studies did not specify findings on changing perceptions of computer science.

3.5.1 Future CS plans

Most divisive in terms of results was the "future CS plans" category which showed similar results between positive, no change, or mixed effects. This category broadly covers a number of future plans involving computer science, including self–reported choice of future college course, considering careers in computing, and definite college choices related to CS. All findings reported fell into these subcategories. Some consideration should also be given to the differences in age brackets (Figure 7) that spanned the studies reviewed and how this may contribute to the variance. These considerations will be revisited in more detail in section 3.6.

Sixteen studies (35%) reported a positive effect concerning future plans to study, work or engage further with computer science; “60% indicated significantly more or more interest in pursuing a career in CS” (Pollock, McCoy, Carberry, Hundigopal, & You, 2004a), “Two thirds of the class commented that they would now consider an IT career” (Lang et al., 2010), “Results show that by the end of their one-week participation in SEP, there was a large increase (+33%) in the number of participants who were moderately interested in pursuing a career in computer science.” (Jung & Apedoe, 2013), “Before attending the conference, only about an average of 32% of the girls responded that they were considering a career in the IT sector. After the conference, this number soared to approximately an average of 80%.” (Thangarajah et al., 2014).

One study compared two popular programming languages; Blockly and Scratch, and reported that those who used Scratch showed less future interest in engaging in computing activities than those who used Blockly (Seraj et al., 2019). Fourteen studies (31%) reported mixed or no change in results concerning the future CS plans of participants; “self-reported orientation to careers in computing showed only a modest increase by the end of the camp (p=.07 for the pre-post difference)” (Webb & Rosson, 2011), “we found a slight positive effect, though not statistically significant, in the responses for the following questions “*I can see myself working in a computing field*,” (Starrett et al., 2015), “no statistically significant change in career interests” (McFarlane & Redmiles, 2020), “The responses to this question varied amongst the participants. The majority of participants who said ‘no’ enjoyed computer science but had other career interest that they thought they would like better” (Robinson & Pérez-Quiñones, 2014). Fourteen of the studies reviewed did not specify findings regarding participants’ future plans to engage with computer science.

3.5.2 Self-efficacy

The self-efficacy category yielded 18 studies (40%) reporting a positive effect: “some evidence of growing confidence in our quantitative data” (Hur, Andrzejewski, & Marghitu, 2017), “Concerning the confidence in programming, the biggest changes were observed between pre Q and intermediate Q. After the introduction to the block-based programming environment, the confidence in programming increased.” (Seraj, Katterfeldt, Autexier, & Drechsler, 2020), “Promisingly, there are indications that after six months of programming, more students have moved beyond naive confidence to feelings of authentic self-efficacy in CS.” (Madrigal et al., 2020). Eight studies (18%) reported either no change or mixed results; “they were more confident that they could achieve good grades in computing courses. At the same time they were less confident that they could learn to understand computing concepts” (Hulsey et al., 2014). Nineteen studies did not specify findings on participants’ self-efficacy following participation in their programme.

3.5.3 Longitudinal Findings

Eight of the papers reviewed reported that their studies engaged in a longitudinal research element. As noted previously, three of these papers concerned iterations of an Australian study the “Digital Divas” programme (Craig et al., 2011; J. Fisher et al., 2015). The types of longitudinal data collected varied between choice of college major, sustained level of interest in CS, and sustained level of computer self-efficacy. The earliest research paper reviewed (Rodger & Walker, 1996) claimed to be engaged in a longitudinal tracking of the high school participants, however no follow-up paper was found in the review.

In the case of the Australian Digital Divas programme (Craig et al., 2011; Lang et al., 2015), the 2011 paper provided a framework for evaluating their programme in the short and long term. Digital Divas designed as a semester-long intervention programme focusing on 12-15 year-old girls within a network of Australian schools. At the point of the 2011 paper's publication, longitudinal data collection had yet to commence. The 2015 paper reported that their long-term intervention resulted in a more sustained changes in girls' perceptions of IT; "We conducted 11 focus groups in four schools involving 33 girls who had participated in Digital Divas one or two years previously. We acknowledge that we cannot draw any hard conclusions from these data because of the limited number of girls we were able to contact and invite to participate in the focus groups. The responses, however, do provide some insights into how sustained the learnings from Digital Divas were. The results indicate that the program has had a sustained impact on those girls."

In one study (Outlay, Platt, & Conroy, 2017) participants returned to a 2-day camp-style outreach programme for a second camp one year following the first, and reported lowered interest in IT careers between the end of the first camp and start of the second. Despite this dip in interest, participants reported higher levels of interest in IT careers between the start and end of the second camp, meaning interest levels were higher at the end of the two years. This raised a question on how sustained levels of interest in IT careers remain in the time following interventions. The study also reported a significant and positive relationship between girls' interest in IT careers and the amount of school computing resources and encouragement they received from parents, counsellors, etc.

Pollock, McCoy, Carberry, Hundigopal, and You (2004b) describe their 8-week summer outreach programme having a longitudinal impact on participants' confidence, decision making and knowledge; "About 70% indicated that their participation improved their confidence some or a lot in their overall ability to be successful", "On decisions made during the 2 years since their involvement in the program, 70% of the participants said that the program had a positive impact on taking subsequent mathematics or computer science courses", "When asked what kind of impact the program had on their interest in pursuing a career in a technical or scientific field, the results were 24% significantly increased interest, 35% increased their interest, 17% had no impact, 12% somewhat decreased their interest" (Pollock et al., 2004b).

Shadow IT is a New Zealand intervention in which high school girls observe a day in the life of a woman working in IT (Hunter & Boersen, 2017). However, a survey administered one year after the event indicated that the influence of the event had not persisted for many of the girls. Findings indicated that the event strengthened the interest of girls previously inclined towards a career in IT, but for other girls, it did not have a lasting influence.

An American study that aimed to engage girls and young women of colour in computing compared longitudinal outcomes of their programme relative to a similar programme targeting boys of colour (Scott et al., 2017). This study took place within a 5-week, 3-summer science, technology, engineering and mathematics (STEM) programme serving underrepresented high school students across four sites in Northern and Southern California. Students are admitted to the program in the summer between 9th and 10th grade, and attend for three consecutive summers. Each course provides 37.5 total hours of instruction per summer, for a total of 112.5 hours. A key objective of the study was to explore whether gender differences in initial interest in majoring in CS persisted into post-secondary education, following participation in the programme. The study reported "promising findings were revealed among a small and self-selected group of students, who chose to enrol in the optional AP CS A preparatory course, there were no gender differences in enrolment and completion of the AP CS A course. In examining longitudinal outcomes however, gender is a significant predictor of majoring in computer science in college, with male students much more likely to major in computer science than female students." (Scott et al., 2017).

The Young Women in Computing program, is an ongoing outreach program in Computer Science at New Mexico State University (Pivkina, Pontelli, Jensen, & Haebe, 2009). Features of the program include summer camps and academic year activities, computing in context, peer mentoring, and role models. The multi-level programme's deployment spans a complete year. The authors reported "a significant improvement in confidence, attitude, and preparation as a result of participation in the program." (Pivkina et al., 2009). Upon graduating high school, 25% of the participants opted to enter the University CS program.

As is evident, longitudinal data on the impact of all-female CS outreach programmes is limited. In the case of the small number of studies reviewed above, the type of data collected and findings reported varied considerably. Nonetheless, a number of encouraging results were reported by the longitudinal studies with regard to sustained confidence, interest in towards computer science, and agency in making college choices. The importance of, and indeed the challenges associated with conducting longitudinal research in this context will be discussed in the following section.

3.6 Discussion

3.6.1 General Overview

This chapter focused on "What are the characteristics of peer-reviewed research conducted on all-female adolescent and pre-adolescent computing outreach activities?" as a guiding question to frame a systematic literature review.

The sub-questions that guided the analysis were as follows:

(1) What attributes, practices and culture do adolescent and pre-adolescent all-female CS outreach programmes share?
(2) What are the aims and objectives set by the programmes?
(3) What type of data has been collected by such programmes?
(4) What findings are reported by the programmes?

Upon analysis, the author found that there is a considerable range of data presented on all-female CS outreach activities. The finding of this review tally with a broader (mixed-gender and single-sex) review by Decker et al. (2016), in that the majority of the reported interventions are from the United States, the reason for this may be that the venues for publication are heavily US-centric.

A majority of the interventions were aimed at the 13-15 year age interval, which is unsurprising given that from early adolescence, girls express less interest in computing and indeed broader STEM careers than boys do (Lapan et al., 2000; Turner et al., 2008). Two-thirds of studies targeted the older, 16-18-year age range, usually focusing on increasing student awareness of computing as a college pathway. One criticism of targeting this age group is that by late high-school, students have not only entrenched perceptions and attitudes towards computing (Cheryan, Master, & Meltzoff, 2015) but many have firmly decided on a career and study pathway. Nonetheless, targeting this age group may still be worthwhile given some of the positive findings from older cohorts reported in this review and that of a large study of female CS undergraduates which reported that women who major in CS are more likely to be undecided in their career plans (Lehman, Sax, & Zimmerman, 2016).

As acknowledged by many of the authors, modest participant numbers are an inhibiting limitation for many of the studies. Over two-thirds of studies had less than 100 participants, and 19 had less than 30 participants. Small sample sizes have implications on the reliability and validity of the results may therefore not be fully representative of a broader population. Such small numbers and the lack of repetition of interventions lead to problems for generalization of the activity's impact and effectiveness.

3.6.2 Programme culture and practice

The majority of programmes took place on college campuses (29 studies out of 45). While this may be due in part to the availability of space to conduct workshops or events, a number of studies cite the utilization of a college environment as a deliberate design element (S. Graham & Latulipe, 2003; Hur et al., 2017).

"Although the venue is not the most important consideration for a project such as this, giving these young women a chance to stay in residence and use the facilities of a university campus is a bonus. All of the sessions were in labs or classrooms on campus. Each student was assigned a university account for use in the lab sessions, but it also allowed the students to access the network or use the lab during their free time. In many ways they experienced life as a university student. When asked "What did you learn at the seminar?" one student wrote: "I learned a lot about how women fit into CS…I kind of got a feel for university life too, and am almost looking forward to it." (S. Graham & Latulipe, 2003, p. 323)

A common element of outreach programmes is the utilization of female CS role models as reported in almost three quarters of the papers reviewed. Role models or mentors typically serve two purposes: to offer direct instruction or teaching support in workshops, and talk to the participants about their career and college experience. There is a breadth of literature available that points to a lack of visible female role models as a contributor to the underrepresentation of women in CS (Asgari, Dasgupta, & Stout, 2012; Beyer, 2008; Stout et al., 2011). In particular, a number of studies claim female students who have had female computer teachers are more likely to study computer science in college (Beyer, 2008), and access to visible role models is related to social modelling, a strong predictor of higher self-efficacy (Stout et al., 2011). It would seem the enlistment of female mentors where possible is entirely appropriate and valuable to outreach programmes. Nonetheless it may be useful to further explore this common component, for example a number of 1-day programmes use a "career talks" format (Frieze, 2005; Hunter & Boersen, 2017), and it would be interesting to examine if relatively short interventions can attribute positive outcomes to their use of role models. There is scope to explore the characteristics of a "good" mentor or role model from the perspective of participants which would help in designing training programmes for outreach models. The inclusion of male role models in this regard is also under-explored, and the possible benefits of male "allies" in the endeavour to encourage gender diversity within computing.

In acknowledgement of strong criticism of the typically didactic and authoritarian practices of undergraduate computing courses (AAWU, 2000), the author sought to explore the role of pedagogy in the non-formal outreach space looking for specified teaching approaches and common practices across programmes. The majority of papers reviewed did not specify any clear or distinct teaching methodology. For those who did, the most commonly reported method was the use of collaborative, team or group learning. Other methods mentioned could arguably be considered as examples of progressive pedagogies; project-based, design thinking, constructivist, and it should be noted that no studies reported on an obviously didactic or behaviourist pedagogy. The author considers that given the very nature of non-formal learning and its subsequent environment, the programmes would by nature follow a more relaxed, collaborative and creative format without having to formally prescribe a specific pedagogy. This theory could be further explored by comparing the outcomes of non-formal and formal CS learning interventions, with particular emphasis on pedagogical practices.

3.6.3 Aims of Programmes

There were a notable number of shared goals identified in the studies examined. These included sparking greater interest in computer science, attracting more women to the field and improving or diversifying perceptions of computer science as a profession. It was encouraging, if not unanticipated, to see that many studies share a number of aspirational common goals. What was of greater interest to the researcher was to establish how strongly the programme aims were linked to data collection methods and findings, to determine how realistic, attainable and measurable these aims are in the context of CS outreach.

3.6.4 Types of Data Collected

The methods by which data was collected varied considerably. Attitudes towards computing, interest in computing careers and perceptions of computing featured strongly in the studies. Another relatively common category was participant knowledge about computing concepts or programming, which were considered by 20% of the studies. The way that data was collected varied from study to study with many different instruments used, but for the most part, this data was collected using pre and post-intervention surveys that were either designed or adopted by the programme researchers. The majority of studies (66%) employed a mixed methods approach to data collection, a slightly higher proportion of studies reported on employing a quantitative approach (11%) than that of a qualitative (9%). Quantitative tools utilized included for the most part self-rating scales, grades, and other methods to assess confidence, perceptions, knowledge and intentions. Qualitative tools included open response type questions and evaluations, interviews and focus groups.

While self-reported interest in future study of pursuing study or a career in computing was the most frequently observed category of data collected (31%), just one study claimed to record students' actual choice of college major. As very few of the studies reviewed engaged in a longitudinal element, results relating to career and college intentions were somewhat limited to self-reported, short term outcomes. These finding of the review were consistent with that of Decker et al. (2016) in their general review of CS outreach programmes.

3.6.5 Findings of Studies

From exploratory reading of the papers, three broad categories were created under which to analyse findings. These were computer self-efficacy, perceptions of CS, and future CS plans.

The category that yielded the most positive results was improving perceptions of computer science. Taking the papers reviewed as a representative sample, it could be argued that girls' CS outreach programmes for the most part yield a positive effect on participants' perceptions of computing with 30 papers reporting positive findings (Table 6). Section 2.5.3 of the literature review discusses the significance of perceptions and stereotypes in the context of girls' predilections towards or away from CS pathways and such programmes can play an important role in dispelling misconceptions and promoting a more positive image of the field.

The second most commonly found finding was an improvement in the participants' computer self-efficacy or self-confidence (40%). While reported as a finding, improving computer self-efficacy was a relatively uncommon *objective* in the studies reviewed (13%), and reported data collection type (18%). This could be attributed to a number of factors. Mixed and qualitative studies may have uncovered common themes related to improved self-efficacy or confidence. The author also considers that the aim of "improving attitudes towards computing" broadly covered personal attitudes including self-image, self-confidence and self-efficacy. This is nonetheless an encouraging finding to be taken from the review process and an indication that outreach programmes result in increased computer self-efficacy for participants. This is promising, given the proposed "gate keeper role" self-efficacy plays in inhibiting girls to considering futures in computer science (Margolis & Fisher, 2002; Meelissen & Drent, 2008) and is discussed in Section 2.5.6 of the literature review.

The most mixed findings category of result was that of "future CS plans" which reported similar results in positive and no change or mixed effects across studies reviewed. Aside from difficulties with gathering longitudinal data and variance in types of data collected, several papers put forward an important consideration that helps to account for these results. This is recognising that there are other factors outside of the control of any intervention or study, which impact on a girl's interest in computer science and influence their later decision-making with respect to further study. In relation to evaluating the success of outreach activities with regard to these external factors, several papers reviewed acknowledged this challenge (J. Fisher et al., 2015; Heo & Myrick, 2009; Robinson & Pérez-Quiñones, 2014). In a paper offering a reflective analysis on the Australian Digital Divas programme, Lang et al. (2015) states the inherent limitations of an outreach programme that endeavours to attract more girls to computing.

"We found that despite designing a programme that delivered a multi-layered positive computing experience, factors beyond our control such as school culture and teacher technical self-efficacy help account for the unanticipated results. Despite our best laid plans, the expectations that this semester long programme would influence students' longer term career outcomes may have been aspirational at best." (Lang et al., 2015, p. 257)

The author contends that these findings open up a number of opportunities to further explore factors that contribute to career and college preferences, to gain a greater understanding of girls' disinclination towards computing paths.

3.7 Conclusion

There have been a considerable number of studies concerning all-female outreach programmes in the past 25 years across the globe. These programmes share a number of distinctive common goals, methods and cultures. In broad terms, all studies share the aim of encouraging girls to explore futures in computer science and it is evident many of the studies share practices that purportedly contribute to an encouraging CS environments for girls including exposure to female role models, progressive teaching methods, and relevant programming activities.

The impact of the programmes reported is generally positive, in particular with regard to improving perceptions of computing and computer self-efficacy in the short-term although modest samples are acknowledged by many of the authors as a key limitation of their studies. What is more difficult to quantify is the impact of programmes in affecting future CS pathways. As very few of the studies reviewed engaged in a longitudinal element, results relating to career and college intentions were somewhat limited to self-reported, short term outcomes, and just one study claimed to record students' actual choice of college major. External factors outside of the control of any intervention which impact on a girl's interest in computer science and influence college pathway decisions should also be taken into account in measuring sustained impact.

The findings of the meta-analysis influence the development of the intervention design and the research methodology. Conducting a structured meta-analysis of the all-female outreach space was born from the author's inability to find such a resource in the early stages of reviewing the empirical data, and to that end she considers its development an important contribution of the dissertation.

3.8 Limitations

There are a number of limitations to this review. This literature review is focused on venues for academic researchers within the computing community. Research data is weak or absent for a number of significant all-female outreach programmes such as CoderDojo Girls, Girls Who Code, or Black Girls Code. These programmes without question contribute positively to the field of girls' computing outreach, however given the difficulty in ascertaining findings from the programmes, they were omitted for consideration in this review.

Secondly no mixed-gender outreach programmes were included in this review. It should be noted that such programmes could be as likely to be successful in encouraging greater female participation in computing. There are a number of studies that examine the nuances of mixed and all-female environments in the context of providing an optimum environment to achieve the set programme objectives for girls (Craig et al., 2013; Kamberi, 2017).

Articles were reviewed from selected venues[40], and these articles served as representation, though the researcher recognises that there may be relevant articles in other venues. There may have been articles that should have been included, but were not. Despite these limitations, the researcher contends that these findings provide a robust and representative sample of the of research conducted in the field of all-female CS outreach.

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[40] The School of Computer Science subject librarian was consulted for guidance as part of the process of identifying relevant papers.

4 Design

Reviewing both the theoretical and empirical data in Chapters 3 and 4 uncovered multifaceted factors that purportedly contribute to the enduring gender imbalance in computer science, and the various efforts by stakeholders at all strata to intervene. While the author does not claim to have designed the intervention from a “blank canvas” after completing a review of literature, she has had considerable input into adapting the intervention over the duration of the study and has also retrospectively considered the initial design of the intervention by colleagues in the context of its theoretical underpinnings.

This chapter will provide a description of the intervention design within the broader context of a pragmatic working outreach model “CodePlus”, an account of how the programme was initially established, the theoretical foundations on which the intervention was built and adapted, details on the author’s role in the development of the programme and contributions to its current design.

4.1 Programme Context, Bridge21

Bridge21 is a model for 21st Century teaching and learning that was founded at the author’s University in 2007 and has since developed as a sophisticated and well-established pedagogical framework. The model’s key components are: project-based, technology-mediated learning; a structured team-based pedagogy; recognition of social learning protocols, and a constructivist rather than an instructive method of teaching (J. Lawlor et al., 2018). The model has been used in a diverse range of student learning activities in both non-formal and formal school settings, including but not limited to mathematics education (Bray & Tangney, 2016), English studies (Kearney, Gallagher, & Tangney, 2020) and teachers’ continuous professional development (Byrne, Fisher, & Tangney, 2015b; Conneely, Girvan, Lawlor, & Tangney, 2015). Out of school workshops usually of 3-4 days’ duration in a variety of curricular contexts at the dedicated Bridge21 learning space on campus are a staple application of the model for adolescent students.

Prior to its application in this study, the model was used in a mixed-gender CS outreach intervention, for Transition Year students (CSTY), to encourage and promote a greater understanding of what studying CS entails (Tangney, Oldham, Conneely, Barrett, & Lawlor, 2009). Research findings from the project showed improved participant attitudes towards and better perceptions of CS, and higher levels of computer self-efficacy post-intervention.

4.2 Development of CodePlus

CodePlus was first established in 2014 as a 1-year pilot programme based on the aforementioned CSTY format and has run continuously since[41]. In consideration of factors found in the literature that promote girls' interest in studying CS, the CSTY programme was adapted, chiefly by emphasising the societal and community relevance of computing and providing an all-female learning environment (Sullivan et al., 2015).

The pilot programme initially took the form of 20-hour introductory workshops to be offered on site in girls' schools as either a one 4-day programme or as modular after-school clubs. 70 girls aged between 12 and 17 across three schools participated in the pilot year.

Provided below are some brief summaries of the key design elements of the CodePlus pilot as designed by Sullivan et al. (2015):

4.2.1 All-female environment

A distinguishing characteristic of the Irish Secondary Education System is the relatively large number of single-sex schools (approximately one third nationally[42]), with more girls than boys attending single-sex schools in post-primary education. These schools provided a natural all-female context in which to conduct the programme and pilot study. This was the first time that a programme utilizing the Bridge21 learning had been developed for a single-sex cohort, but was justified given the primary objective of the exercise was to afford girls an opportunity to explore pathways in computer science.

4.2.2 Learning Activities

Based on the approach of CSTY's activities combined with relevant literature on encouraging girls' participation in CS, the CodePlus pilot initially covered three broad areas; Computers in Society, Computational Thinking and Computer Programming. With regard to Computers in Society:

"In the early sessions, the students, working in teams of four, looked at how they use technology in their daily lives and did online research about how technology is currently used in areas such as medicine, fashion, education and entertainment. They also came up with ideas for new pieces of technology that could solve problems in the same areas. The aim here was to help the students understand the influence technology has on our lives and to see the broad range of potential career paths that computing might involve." (Sullivan et al., 2015, p. 3)

The author considers that this modified aspect of the workshops was particularly relevant given the literature suggesting that women and girls may become more interested in computing and programming activities when they are presented in a broader societal context (Buechley, Eisenberg, Catchen, & Crockett, 2008; A. Fisher & Margolis, 2002; Klawe, 2013), as discussed in section 2.6.3.

Computational thinking, procedural and algorithmic thinking type tasks were used regularly as warm-up activities within sessions. These were intended to make explicit the algorithmic processes of

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[41] The Covid19 Pandemic presented a number of challenges to the 2020/21 delivery of the programme which was moved to a fully online format. Participants involved in study did so from 2015-2020 which pre-dates these disruptions and significant changes in the delivery of the programme.

[42] https://www.education.ie/en/Publications/Statistics/Statistical-Reports/2018-2019-statistical-bulletin.pdf

computers for the students and included online games such as Blockly, logic-based puzzles and pen and paper activities with several borrowed from the widely used CS-Unplugged teaching materials (Bell, Alexander, Freeman, & Grimley, 2009).

Finally, following the approach of CSTY, Scratch was chosen primarily as the programming language of the workshop sessions. It was anticipated that the majority of participants would have little or no previous programming experience and given the short duration of the workshops (20 hours), Scratch empowered learners to create programs immediately through it's graphical "drag and drop" command blocks without the pre-requisite mastery of text-based language syntax (Tangney et al., 2009). In teams, students created animations and games and through these scaffolded tasks they were introduced to core concepts in programming such as initialisation, looping, variables, conditional statements, events and concurrency. For a number of able students, several more challenging programming tasks were introduced with AppInventor and the Kinect2Scratch extension in which a Microsoft XBox Kinect motion controller could be used in conjunction with a Scratch project.

4.2.3 The Bridge21 Activity Model

As aforementioned, at the time of the CodePlus pilot the Bridge21 pedagogical model had been established for a number of years and employed in a variety of educational programmes and studies. Moreover, its use in the context of the CodePlus pilot was adapted from the mixed-gender CS outreach programme (CSTY).

The Bridge21 activity model (Byrne, Fisher, & Tangney, 2015a) provides a conceptual framework for the design of activities and consists of seven consecutive steps. Sessions typically start with (1) a'set up phase' in which introductions are made and teams are formed. This is followed by a (2) 'warm up' activity designed to encourage divergent thinking and get the teams thinking creatively and working together. Next is the (3) 'investigation' stage which promotes convergent thinking and sets the context of the workshop. Teams define a problem and research the context in preparation for planning and creating some digital artefact. The (4) 'planning phase' has teams discuss and assign tasks and roles and agree a schedule for the delivery of work to be completed. The creation phase is a cyclical process in which teams (5) 'implement' and iterate on their design. Finally, teams are invited to (6) 'present' their work to their peers and share what they have learned. A final (7) 'reflection' phase is used to consolidate the learning. A visual representation of the activity model is provided below:

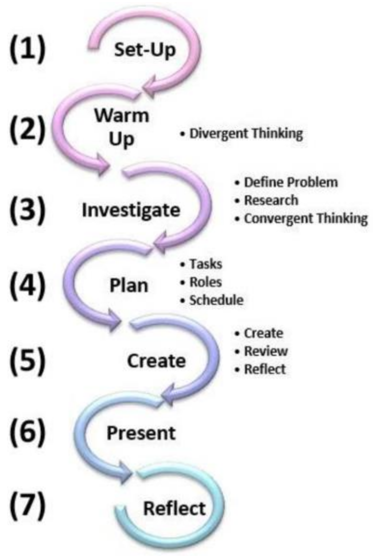


Figure 12: Bridge 21 Activity Model (Byrne et al. 2015a)

The pilot programme fully adopted the learning model as a scaffold for the activities described in the previous sub-sections. Over the course of the workshops whether delivered in the full 4-day run or more modular in nature (e.g after school format), the activity model was followed several times with distinct projects such as creating an animation or a game. Within small teams of 4, a paired programming method (Hanks, Fitzgerald, McCauley, Murphy, & Zander, 2011; Werner, Hanks, & McDowell, 2004) was utilized as students worked with a ratio of 2-1 computer. Teams were expressly instructed by the facilitators to discuss and design their projects within their teams, utilising the whiteboards and markers provided, before writing their code.

While Sullivan et al. (2015) suggested that the adoption of the activity model was a potentially powerful way in which to deliver a CS outreach programme for girls, it was acknowledged that further research should be undertaken to explore the pedagogical implications of the programme.

4.3 Author's Role in Programme Development

The author joined the programme team in 2014/15, taking programme lead for the 2015/16 academic year. The author registered as a PhD student in the 2017/18 academic year and from that time until the present took lead of running the programme and the research study in tandem. 43 workshops of 4 days each were run over a 5-year period with a cohort of over 1000 girls.

Throughout the pilot and subsequent years, the programme operated on a modest budget funded by philanthropy and other sources of sponsorship. Several national computing and STEM bursary organisations funded the programme and a number of tech companies supported the project through funding, providing volunteers for the workshops, and donating equipment.

The breakdown of data collection stages and workshop cohorts was as follows;

Short-term data

Short-term survey, n=856, 2015-2020 (Appendix C)

Qualitative reflection questionnaire, n=418, 2017-2020 (Appendix E)

Longitudinal data

Longitudinal survey, n=76, 2019-2021 (Appendix D)

Individual Participant Interviews, n=4, 2021

Short-term quant	**Short-term qual**	**Longitudinal Survey**	**Interviews**
2015/16			
2016/17	2016/17		
2017/18	2017/18	2019/20 (2017/18 cohort)	
2018/19	2018/19	2020/21 (2018/19 cohort)	2021
2019/20	2019/20		

Table 7: Breakdown of data collection stages and research cohorts

The following sub-sections detail the amendments made to the programme in its pilot form by the author based on pragmatic and theoretical rationale:

4.3.1 Programme Setting and Participants

From 2015 onwards the programme was focused on providing a four-day intervention style workshop in the dedicated Bridge21 learning space on the university campus. This shift was justified as a conscious design element by the author in light of the literature regarding similar CS outreach interventions for girls that place a high value on situating their programmes within the college or university campus (S. Graham & Latulipe, 2003; Hur, Andrzejewski, & Marghitu, 2017; Robinson, Perez-Quinones, & Scales, 2016), discussed in Section 3.6.2. The physical design of learning space had also been purpose built prior to this project to support a social constructivist and structured team-based pedagogy (J. Lawlor et al., 2018), providing an ideal environment for the activities and learning style.

Moving the programming setting from schools to the university campus also meant that schools could be mixed for the workshops, providing an opportunity for students to work with others and make new friends outside of their usual peer groups. Teams would be formed by a mix of schools where possible[43] and organised into teams by the facilitators to avoid self-selecting friendship groups.

It was theorised that these strategies would lead to a more immersive and engaging experience for the participants on the programme, based on previous research findings regarding the application of the learning model in the context of the on-campus learning space (J. Lawlor et al., 2018; J. Lawlor et al., 2016).

The age profile of the participants also narrowed significantly. In the pilot, the programme was open to girls of all class levels within the secondary school resulting in an age demographic of 12-17 years. From 2015 onwards, the programme was exclusively open to girls from the fourth of the 6-year Irish secondary school cycle who were aged 15-16. In the Irish education system this is an elective year for students before the beginning of the 2-year senior school cycle. In this transition year, students have a more relaxed curriculum relative to the junior and senior cycles and are given a number of opportunities to explore career and college pathways through work experience and modular courses. Accordingly, transition year (TY) is acknowledged as a time when many students begin to make key decisions regarding third-level education, including choosing senior cycle subjects and levels that affect college and university admissions. Students typically graduate from school following their sixth year and progress to third-level education, training schemes or employment.

The decision to restrict the programme to the TY cohort was largely a pragmatic one. As aforementioned, the TY curriculum is more relaxed in its structure and over the course of the year students are typically released for periods of time from the school to pursue modular courses, class trips and work experience. The programme and research study would have easier access to this year group than other years bound by preparation for state examinations. It was also viewed as a key period in which an intervention programme could make an impact, coinciding with the period of mid-adolescence where a drop-off in girls' STEM interest is known to occur (Lapan et al., 2000; Turner et al., 2008), and in the context of the Irish system at a time when subjects choices for the senior cycle are made.

4.3.2 Female Role Models and Career Talks

In light of the literature on the importance of female CS role models for girls (Barker & Cohoon, 2006; Margolis & Fisher, 2002; Spertus, 1991) discussed in Sections 2.6.1 and 3.6.2, the author recruited women from the technology industry and CS undergraduate students to volunteer during the CodePlus workshops. The intention was to provide visible female role models for the participants who could offer both practical help with the activities and also act as ambassadors for the field of CS. Participants were encouraged to approach the volunteers with questions about studying and working in CS at any stage during the 4-day workshops.

A key addition to the workshops were the speaker sessions in which the volunteers give an informal talk about their experience of studying and working in the field. These talks were usually organised in partnership with tech companies who would provide a panel of female volunteers scheduled to visit

[43] In a small number of cases due to school timetabling and other factors outside of the author's control, workshops comprised of a single school group. Typically, workshops comprised of 3-4 different schools.

the learning space during the workshops. A template (see Appendix B) was provided for all volunteers to create slides with photographs and programme participants could ask questions. On several occasions some local tech companies hosted these sessions on their premises during the 4-day programme and the students had the additional experience of a visit to the company (alongside welcome refreshments and other goodies or “swag”!).

The speaker session element of the workshops was extended in 2018 as an ancillary activity to the core programme workshops. Both large-scale talks were hosted in a number of tech-company sites where several hundred students at a time were hosted for panel-style events and an additional programme was organised within schools with volunteers despatched to deliver talks within the classroom. These activities were intended to broaden the reach of the programme, albeit with a shallower engagement than the core 4-day workshops. Due to pandemic restrictions in 2020 and 2021, the talks programme was adapted into an online format and a number of panel sessions were successfully hosted via video conferencing software. With regard to the research study, data collected from the stand-alone talks are not included, nonetheless the longitudinal survey and interview protocol makes provision for establishing whether research participants received an additional in-school talk or visit to a company.

While recognising the importance of implementing a suitable female mentoring team, it is prudent to note that prior to CodePlus, mentoring had been well established as an integral element of the Bridge21 learning model (J. Lawlor et al., 2018). The author considers that by modifying this element of the model in response to the literature and providing female role models, the Codeplus programme developed in its merit as an intervention.

Figure 13: Students asking a company volunteer some questions

4.3.3 Changes to Learning Activities

Upon taking lead of the programme, the author continued with much of the pilot activity format and activities, notably the Scratch animation and game design activities and use of CS Unplugged activities. One key change made to the format of the workshops was to modify the "computers in society" activity in which teams would create a video based on brainstorming and creating a prototype of a future technology product or service. This activity was typically run on the first day of the programme and served primarily as a means to encourage early team building in creating a digital artefact. This task constituted a large part of the first day of programme and while it did include relevant discussion on the use of technology in present and future life, it did not consist of any programming content. Preliminary reading of the written survey data and other feedback from participants and teachers indicating a desire to begin coding earlier in the workshop led the author to a changing this format in 2017/18 to begin coding on the first day of the programme and a move onto the text-based coding language Python later in the week.

Aspects of the initial "computers in society" were assimilated into a new activity using hardware kits: MakeyMakey, Arduino, Raspberry Pi and micro:bit. Teams brainstormed ways in which computers are encountered in our daily life and broke down the various inputs and outputs processes involved in different programs. Students then created simple working prototypes of products or services using the kits

The author adopted "Python from Scratch" resources developed by Byrne et al. (2015b) that linked programming concepts and functions in Python to those that the participants had previously encountered with Scratch. These resources served as an introduction to Python with which participants could create simple programs that put the concepts into practice such as calculators, number guessing games etc.

The author also expanded on the computational thinking exercises of the pilot, introducing a number of card sorting algorithms in which teams used packs of playing cards to solve sorting problems. As a warm-up to the game design project, the author created a maze upon the floor of the learning space with tape and had students use blindfolded mascots to "walk through" the maze acting as the game characters and other objects (hero, villain, lives) suggesting the code that was required as the game was developing. This activity was intended to make explicit and visual the processes of broadcasting, variables and operations within Scratch.

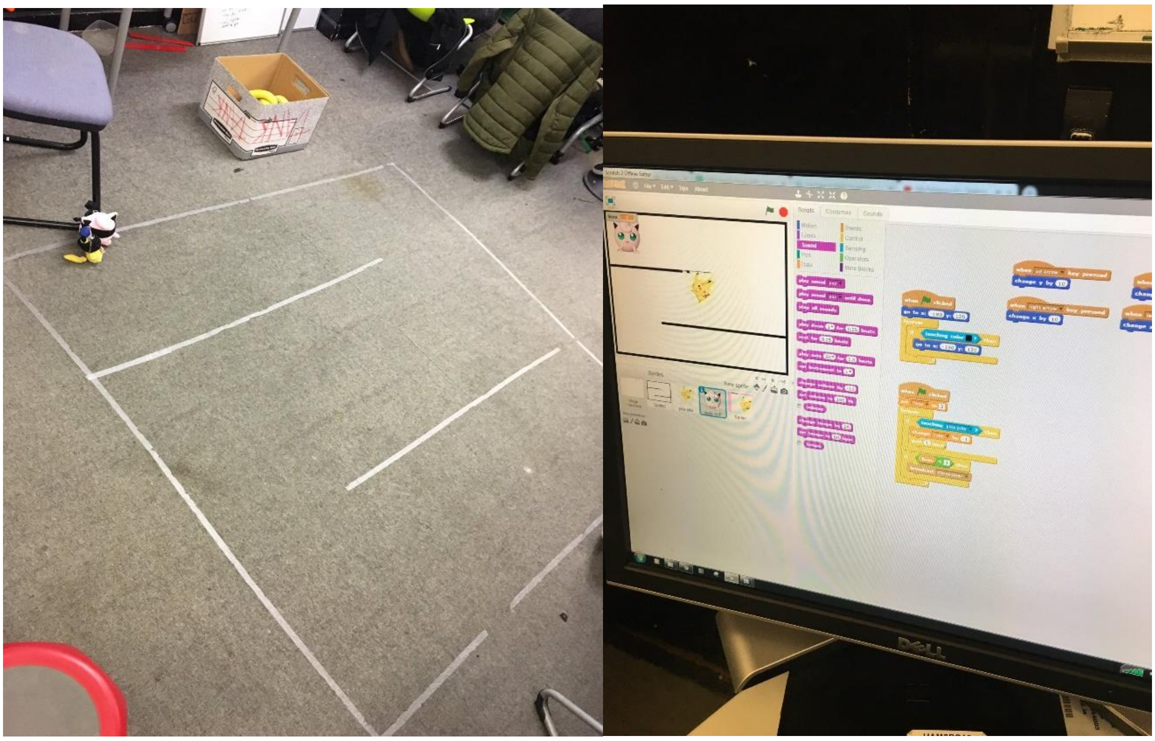


Figure 14 Physical Maze Walk-Through Activity

4.3.4 Advanced Week Programme (CodePlusser)

Following the pilot year, an “advanced week” version of the programme, informally and fondly dubbed “CodePlusser” was developed by the author for a small number of keen students who had participated in the core introductory programme. The objective of this supplementary programme was to provide a deeper engagement opportunity for students and to host a “showcase” style event in which to promote the programme to potential sponsors and other stakeholders. For the final showcase event, a suitable venue on the university campus was booked and a graduation ceremony was held for all participants of the introductory programme who had attended that year. All programme participants were invited to attend and to receive a certificate, with prizes awarded to stand out teams and individual students.

Modelled on a prior mixed-gender project under the Bridge21 research body (Byrne, O’Sullivan, & Sullivan, 2016), the advanced week workshops were by design “hackathons”. In the introductory workshop, students would have had a number of small projects to complete during the week whereas the advanced week consisted of a sustained week-long project with a focus on each team preparing a “product” from a broad brief designed to afford them a large degree of creative ownership over the project. Teams used a variety of technologies available to them to create working prototypes which were then included as part of the showcase where the students would present their projects to their peers, teachers and other guests.

Due to timetabling and resource related restrictions within the project, the advanced workshops were available only to a small cohort of students each year (approximately 25-30). Nonetheless, students who had participated in the introductory programme could also apply to participate in the comparable

Bridge21 “InventWeek” mixed-gender hackathon. While isolating the short-term effects of participation in the advanced weeks was not a central element of the research, the longitudinal study tools do seek to establish whether participants had attended the programme and/or the mixed-gender invent week.

4.4 Design Summary

As stated at the outset of the chapter, it would be misleading for the author to claim credit for the initial design of the programme intervention with which she has given full acknowledgement to her colleagues and fellow researchers. Nor can she claim that the design of the learning intervention was preceded by her own extensive review of empirical and theoretical data.

With that said, it is worth acknowledging at this point, the inherently pragmatic nature of a functioning outreach programme such as CodePlus with a primary objective of delivering a quality programme for participants, while navigating a number of practical and logistical challenges with key stakeholders. This is not to deflect from the strong theoretical underpinnings of the intervention's design that have been considered by the author and her colleagues and discussed in this chapter.

To put it another way, the CodePlus programme was "up and running" by the time that it had become the focus of the author's doctoral research study. This is not unusual in the field of educational and practitioner research where conditions are not always as clinical and procedural as in other disciplines. To separate the role of the author as practitioner and as researcher with regard to the programme is difficult, however the author acknowledges the clear distinction between the two and the following Chapter 5 Methodology will elaborate on the latter.

5 Methodology

Humankind has long been concerned with understanding its environment and the nature of the phenomena it presents (Cohen et al., 2013). The means by which this "search for truth" is entered into can be classified by three broad categories: experience, reasoning and research (Mouly, 1978). Cohen et al. (2013) consider how these three strategies are not mutually exclusive but have a tendency to overlap and become complementary where complex problems are presented. Borg and Gall (1963) considered research to be a combination of both experience and reasoning, thus regarded as the most viable approach to the discovery of truth, in particular when concerning the sphere of natural sciences.

The field of educational research is comprised of numerous standpoints including scientific and positivist, naturalistic and interpretive, and mixed methodologies that combine aspects of both theoretical foundations. Assumptions about the nature of knowledge are fundamental considerations when conducting educational research. A researcher's personal beliefs regarding the nature of reality (ontology) and of knowledge (epistemology) inform the chosen research approach which in turn has implications for methodological considerations, instruments and data collection (Cohen et al., 2013).

This research study examined the effects of a CS outreach intervention for girls, not only evaluating the intervention itself, but providing further research on several areas pertaining to the central phenomenon under investigation; the under-representation of girls and women in the field of computer science. To meet the challenge of delivering this research, due consideration was given to a range of approaches before a definitive methodology was adopted.

This chapter will first outline the methodological rationale for the study, discuss alternatively considered frameworks before describing the chosen research methodology. The research methods including the particular tools and specific methods for data collection and analysis are then presented including the adoption of previously validated instruments. The reliability of the study and ethical considerations of the study also discussed in detail.

5.1 Methodological Rationale

There is neither "one" or "right" way to approach research. The field of enquiry has many different approaches each with its own traditions, conventions, histories, internal disputes and relationships with each other. When a researcher selects an approach to doing educational research over another it is as much to do with personal and institutional politics as it is to do with answering the research question. Stating a "knowledge claim" is to approach research with certain assumptions about what learning will be discovered and how it will be discovered during the inquiry (Creswell, 2003). Creswell (1994) outlines four main schools of thought from which knowledge claims are drawn: post-positivism, constructionism, advocacy/participatory and pragmatism.

Positivist and post-positivist approaches reflect a deterministic philosophy in which causes determine effects or outcomes. As these approaches are reductionist, with a goal of reducing ideas into measurable variables to be tested, the approach can also be referred to as quantitative research. Within this paradigm, knowledge developed through the post-positivist lens is based on the observation of an objective reality.

By contrast, socially constructed (also called naturalistic and interpretive) knowledge claims argue that meanings are constructed by humans and often these subjective meanings are negotiated historically and socially. This paradigm is grounded in the experience of people, and open-ended or qualitative methods are favoured to gain an understanding of these experiences. As opposed to the deductive style of hypothesis testing in the positivist tradition, constructivist knowledge inquirers generate theories or patterns of meaning inductively from data collected. Researchers recognise that their findings are interpreted in the broader context of their own experiences and background as they position themselves in the inquiry.

A third paradigm asserts knowledge claims through an advocacy or participatory approach. In this approach, the researcher does not assume a neutral stance but rather an emancipatory and transformative agenda intrinsically linked with a political position. Advocacy research goes further than the constructivist approach in that participants tend to be active collaborators in the research inquiries with the objective of bringing about social change.

Finally, pragmatism is a paradigm with many forms that view knowledge as arising from actions, situations and consequences as opposed to the antecedent conditions of postpostivisim. Pragmatism is essentially a practical rather than ideological epistemology, as Denscombe (2008) states it is "practice driven" (p.280) and concerned with "what works" (Patton, 1990). On that basis, a pluralistic approach can be taken to understand a problem, or in other words, a mixing of quantitative and qualitative methods.

The above knowledge claims, strategies and methods all contribute to a research approach that is either quantitative, qualitative or mixed. Creswell (2003) considers three key factors in how an approach may be chosen which are: the research problem, the personal experiences of the researcher and the intended audience for the report.

It should be noted that when deciding an appropriate research framework for the dissertation, strong consideration was given to the advocacy or action research approach; The central thrust of the research was to provide a positive intervention for a marginalized group based on findings from the literature, empowering girls to explore potential futures in the field of computer science. This goal aligns itself to the several of the purposes of action based research as stated by Cohen, Manion, and Morrison (2011, p. 129), in particular "To plan, implement, review and evaluate an intervention designed to improve practice", "to promote equality democracy" and "to link practice and research". Nonetheless, several aspects of the study were at odds with the key characteristics of action research which includes participants as co-researchers and the cyclical, reflective nature of action research (Cohen et al., 2011; Creswell, 2009; Denscombe, 2010). While the author contends that the research aims were emancipatory in nature, it would not have been feasible to involve the research cohort as co-researchers due to a number of factors including the large cohort numbers and limited contact time access given the age of participants. Furthermore, action research has a central tendency to deliver solutions to local and community problems rather than delivering more generalizable contributions to the research problem under investigation (Cohen et al., 2011; Creswell, 2009). On this basis, action or advocacy/participatory research was eliminated as an overarching research framework for the study, although as elements of research approaches are rarely mutually exclusive, the author does recognise how elements of the action research tradition informed the design of the study, in particular the in-depth interviews with programme participants which was strongly feminist in its design as a means to allow participants to share personal narratives (Creswell, 2009; Ezzy, 2002).

With regard to the research problem this study seeks to address: examining the impact and particular design elements of a CS outreach programme for girls, the author acknowledges the merits of mixed methods design as a means of meaningfully combining elements of both quantitative and qualitative approaches. Quantitative methods and tools such as surveys were deemed appropriate in identifying and examining various factors pertaining to the central phenomenon under investigation while qualitative methods such as open-ended written reflections and interviews would provide a means to better understand the problem from the perspective of participants. The author considers the influence of her own experiences and preferences in the context of choosing the approach. As an educational practitioner, the author has strong leanings towards a pragmatism as an approach to research and would advocate for Creswell (2003)'s view that "neither life nor research is simply about numbers". Furthermore, the author acquired some considerable experience and training in both the quantitative and qualitative disciplines through her acquirement of a Post-Graduate Certificate in Statistics and enrolment in other course such as Research Methods and Use of Software in Qualitative Data analysis courses during the period of the study.

This research draws on data that is quantitative in nature in order to ascertain whether changes in key attitudinal and intentional variables emerged through participation in the intervention. An examination of how these changes occurred however, required more interpretive methods. The interpretivist method could also uncover new factors and perspectives on the central phenomenon under investigation and provide a means to uncover causal relationships.

Based on these considerations, a combination of both qualitative and quantitative methods–a mixed-methods, pragmatic approach was deemed most appropriate for this study.

5.2 Research Framework

While the research methodology and approach relates to the rationale, beliefs and ideas underpinning the research, research methods, are the collection of tools and techniques used to collect, analyse and interpret the data. When philosophy, strategies and methods are combined, they provide distinctive frameworks for conducting research (Creswell, 2003).

An additional challenge in addressing the design of the research framework was that an initial data instrument had been utilized in the early years of the programme (Sullivan et al., 2015) with data gathering in place prior to the author commencing work on her doctoral research in 2017. A considerable bank of data had already been collected with this tool which was likely to be of interest and value to the study, nevertheless it should be duly noted that this was a factor in influencing the design of the formal research model and the adoption of the instrument shall be discussed in section 5.3.1 of this chapter.

Procedures for conducting mixed methods studies have emerged in response to the need to clarify intent to mix qualitative and quantitative data and to support researchers to develop coherent designs from complex data and analyses (Creswell, 2003). Leading works include Tashakkori and Teddlie (2003), Creswell (1999), and J. C. Greene, Caracelli, and Graham (1989).

Creswell (2003), proposes a checklist of components for researchers to consider in the design of a mixed methods study. These include the need to develop a visual model for the approach, detailed procedures for data collection and analysis, the researcher's role and the structure of the final report.

Researchers should convey both the specific strategy that they intend to use and the criteria employed in using this strategy. Cresswell, Plano Clark, Gutmann, and Hanson (2003) provide a matrix as adapted in Table 8 below, illustrating the four key decisions that inform a mixed methods strategy of inquiry:

1. What is the implementation sequence of the qualitative and quantitative data collection?
2. What priority will be given to the qualitative and quantitative data collection and analysis?
3. At what stage in the study will the quantitative and qualitative data and findings be integrated?
4. Will an overall theoretical perspective be used in the study?

Implementation	***Priority***	***Integration***	***Theoretical Perspective***
No sequence Concurrent	Equal	At data collection	Explicit
Sequential-Qualitative first	Qualitative	At Data Analysis	Implicit
		At Data Interpretation	
Sequential- Quantitative first	Quantitative	With some combination	

Table 8: Decision choices for Determining a Mixed Methods Strategy of Inquiry (Creswell et al. 2003)

These considerations were taken into account in the choosing of a suitable mixed-methods strategies from three distinctive models, each examined in detail in the following sub-sections.

This mixed-methods study was also designed with both a short-term and a longitudinal element. The rationale to include both short-term and longitudinal components of the design was in response to criticism of the outreach space from a research perspective, in particular a lack of longitudinal studies to evaluate the impact of interventions (Decker et al., 2016), Section 3.5.3. The term longitudinal is used to describe a variety of studies that are conducted over a period of time, consisting of survey or other types (e.g. case study) (Cohen et al., 2013). The appeal of longitudinal research is that it can enable a researcher to establish causality and to make inferences (Cohen et al., 2013), to highlight constants and changes over time in respect to one or more variables, and identify long-term or "sleeper" effects (Ruspini, 2002).

While longitudinal studies have a meaningful role in the sphere of educational research (Cohen et al., 2013), with the potential to provide rich data tracing changes over time with great accuracy (Gorard, 2001), the nature of this research poses a number of distinct challenges. Primarily, longitudinal studies suffer from participant attrition (Ruspini, 2002), in order to address this it is recommended that a longitudinal study should start with as large a sample as is practical and possible to allow for drop-out (Wilson et al., 2006). The second concern in relation to longitudinal studies is that of establishing causation as "the roots and causes of the end state may be multiple, diverse, complex, unidentified and unstraightforward to unravel" (Cohen et al., 2013, p. 273). The researcher fully acknowledges these concerns with regard to the validity, reliability and generalisability of the study discussed in Section 5.4.

Four distinctive data collection intervals were identified in the design of this study as illustrated in Figure 15. Times 1 and 2 concerned short-term data directly before and following the intervention and times 3 and 4 concerned the longitudinal aspect of the research to coincide with the college application choices and subsequent college pathways of participants. A breakdown of the data collection tools utilized at each interval is provided in Section 5.3.

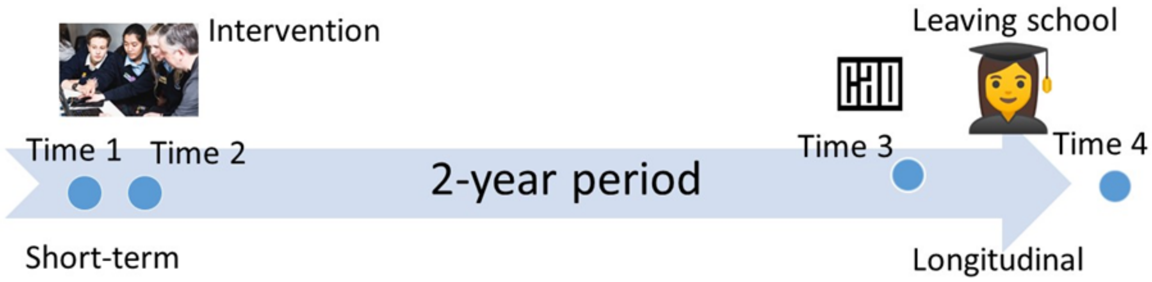


Figure 15: Diagram of Data Collection Timeline

The following sub-sections will examine three alternative mixed-methods research strategies that were considered in the choosing of a suitable framework for the study. In keeping with the approach of Creswell (2003), visual models of each strategy are provided along with specific procedures of data collection and analysis.

5.2.1 Sequential Explanatory Strategy

This approach is characterised by the collection and analysis of quantitative data followed by the collection and analysis of qualitative data. In this model, a quantitative data lead is taken (note the use of capital letters to denote dominant QUAN data in Figure 16), then qualitative results are used as a means to interpret and explain the results from the quantitative phase of the study with the two methods combined at the integration stage of the study (Creswell, 2003). The visual model illustrates the sequence of data collection and analysis and is annotated with the data collection tools with respect to the study.

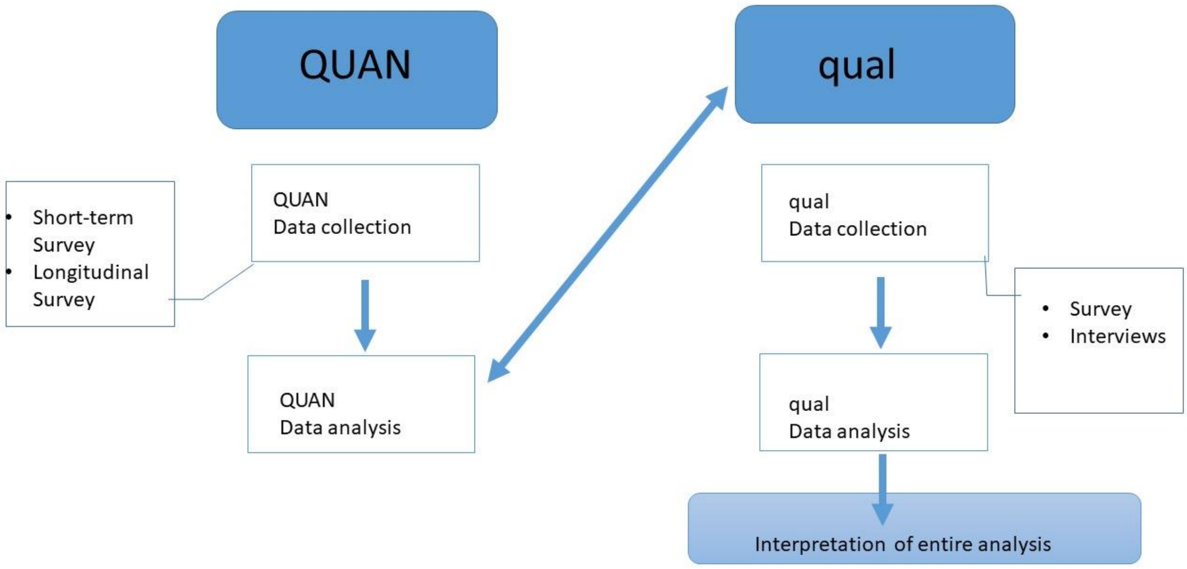


Figure 16: Sequential Exploratory Design

The sequential exploratory design, as adapted from Creswell (2003, p. 213), was an early contender for a mixed methods framework. The design is straightforward and easy to implement. As aforementioned, prior to the author taking lead of study, a quantitative survey tool had been used in the context of the programme and validated by virtue of a published pilot study (Sullivan et al., 2015). This precedent was considered a sound approach by the author and thus incorporated into the model whereby results of the quantitative instrument could be explained by a second stage of qualitative data collection consisting of an open ended written survey and interview data.

The main weakness of this model as an approach is that it does a poor job in reflecting the longitudinal element of the study. A quantitative, longitudinal survey was designed by the author based on short-term findings and a further review of literature. Accordingly, this data collection and analysis would take place following a phase of both quantitative and qualitative data analyses.

5.2.2 Concurrent Triangulation Strategy

The second model that was given strong consideration by the author was that of a concurrent triangulation strategy. Creswell (2003) recognises the value of this model in utilizing separate quantitative and qualitative methods as a means to offset the inherent weaknesses associated with either method alone, or to confirm, cross-validate, or corroborate findings within a single study (J. C. Greene et al., 1989; Morgan, 1998; Steckler, McLeroy, Goodman, Bird, & McCormick, 1992). It differs significantly from sequential strategies such as that described in the previous sub-section by the concurrent nature of its data collection. Figure 17 below illustrates the model, again annotated with the study's data collection tools:

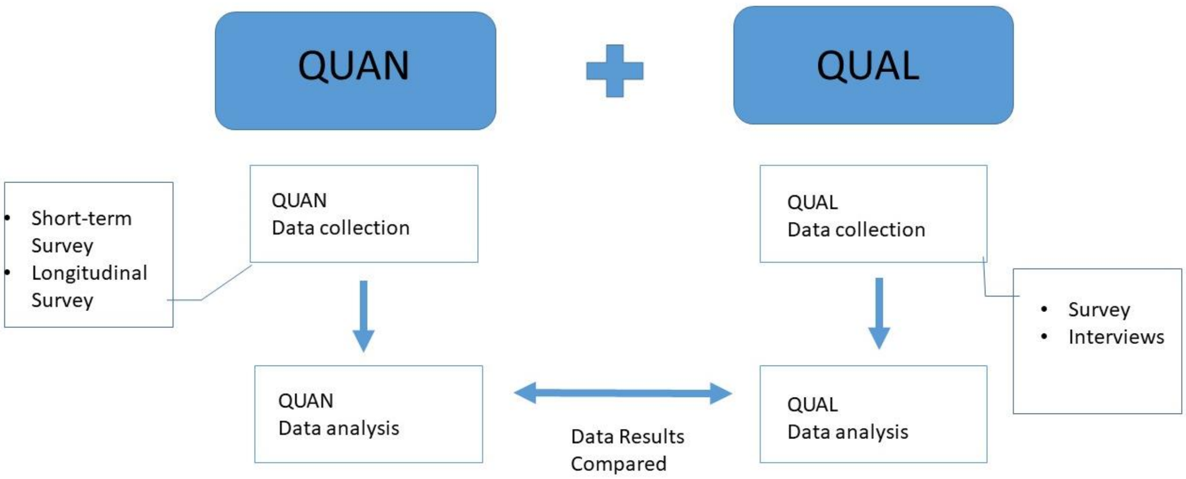


Figure 17: Concurrent Triangulation Strategy

There were a number of advantages to this design. Foremost, it reflected the concurrent collection of qualitative and quantitative data in the short-term phase of the study. At the time of considering design models the author had also planned to collect quantitative and qualitative longitudinal data concurrently. It was envisaged that this approach could provide a greater triangulation of data with substantiated findings. However, this model also fell short of demonstrating the longitudinal element of the study and the upon consideration the author maintained that the design would be quantitatively led. The interpretive phase as illustrated in Figure 17 suggests a convergent approach to the analysis of data, which in practice can be difficult to accomplish. In reality, quantitative and qualitative data was analysed in a more sequential than convergent manner.

Thus, a model was needed that reflected the quantitatively-led nature of the two key stages (short-term and longitudinal), the concurrent nature of data collection stages and the longitudinal aspect of the study.

5.2.3 Longitudinal Concurrent Nested Strategy

Similar to the concurrent triangulation strategy, a concurrent nested strategy collects quantitative and qualitative data simultaneously in one data phase. However, a key distinction is that the nested approach adopts a predominant qualitative or quantitative method within which the secondary method is embedded or nested. Figure 18 below as adapted from Creswell (2003, p. 214) illustrates the nested nature of the data collection whether following a quantitative or qualitatively dominant method. In both scenarios, data collected from the dominant and embedded methods are mixed in the analysis of findings.

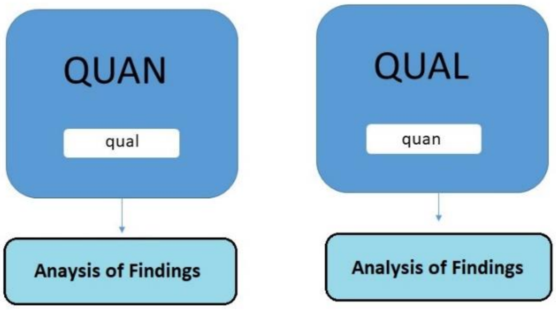


Figure 18: Concurrent Nested Strategy (Adapted from Creswell 2003)

The concurrent nested model can serve a number of purposes, such as a researcher gaining broader perspectives from using both the embedded and dominant method rather than the dominant method alone (Creswell, 2003). For example, Morse (1991) suggests that qualitative data can be used to describe an aspect of a primarily quantitative design that cannot be easily quantified. The author considered this in the context of the research study in that the quantitative tool could answer the "what" in terms of the measurable variables of the intervention effects, whereas supplementary qualitative data could answer the "how". This relates to the research questions of the study with the corresponding methodology noted in brackets:

RQ1: What is the short-term effect of the intervention's approach? (Quan)

RQ2: What are the longitudinal effects of the intervention's approach? (Quan)

RQ3: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term and longitudinal change? (Qual)

Despite the strengths of this approach outlined above, there are some limitations to consider in its application. As the two methods are not equal in their priority, this impacts on the balance of data type and potentially unequal evidence. Creswell (2003) also cautions that data should be transformed so that they may be meaningfully integrated within the analysis phase, a process for which there is little guidance available. The author considers that with respect to the latter issue, she pragmatically adapted Creswell's concurrent nested strategy to suit the objectives of the study: e.g.: in broad terms quantitative and qualitative data were analysed separately rather than integrated, notwithstanding the ways in which modular data collection and analysis influenced subsequent modules and stages.

While the author felt that the nested nature of the third model was a better fit than the previous sequential and concurrent strategies, Creswell (2003) model was confined to one, singular data phase. The author further adapted the model to accommodate two key phases of data collection (short-term and longitudinal). Figure 19 illustrates the model with both phases and data collection tools:

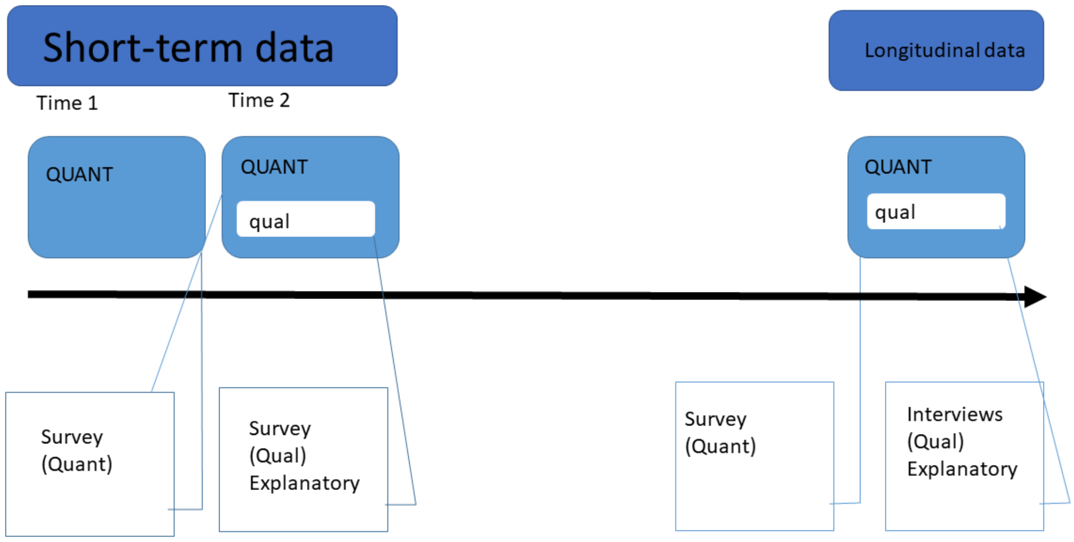


Figure 19: Longitudinal Concurrent Nested Strategy

The short-term data collection phase would be quantitatively-led with the administration of a validated survey at two intervals (pre and post-intervention) to measure the key attitudinal and intentional variables. Nested within the Time2 interval, a second qualitative, reflective written survey would also be administered in order to allow the author to gain further perspective from open-ended data. Following a period of approximately two years to coincide with the participants' college choices, a longitudinal survey would be administered to investigate the enduring effects of the intervention and other mediating factors that affect college course decisions. Finally, a sample of participants who choose to follow the pathway of computer science would be interviewed in the most open of the methods used in the study (interview), providing rich narratives of how they had arrived at their decision to do so.

In the context of this chosen strategy, the following section will describe the data collection and analysis methods.

5.3 Data Collection and Analysis Methods

This section will describe the instruments used for data collection in this study, the basis for each instrument's adoption or design by the author, and an outline on how the data was analysed. Cohen, Manion, and Morrison (2007) provide a comprehensive review on the chief instruments used in educational research which provided sound theoretical and practical support for the author in considering the tools to be used in the study.

5.3.1 Quantitative Data

5.3.1.1 Short-Term Survey

Both the short-term and longitudinal phases of this research are quantitatively led, utilizing surveys. As previously stated, a quantitative instrument had been in use by the programme and validated in the pilot study (Sullivan et al., 2015) its format keeping with that of the CSTY study survey (Tangney et al., 2009), designed to measure changes over the course of the workshop in key attitudes, third level intentions, the range of courses of study participants were considering, and understanding of what a CS degree involves. This instrument was itself developed from validated components from previous studies including the computer self-efficacy scale (Eachus & Cassidy, 1996; Papastergiou, 2008) and perceptions of the CS profession (Papastergiou, 2008) including gender-based perceptions which were in turn developed from previous research (Craig, Galpin, Paradis, Turner, & Martin, 2002; Galpin & Sanders, 2002; Moorman & Johnson, 2003). The CSTY survey was also designed to gather demographic information, maths grades and prior programming experience which in turn was adopted by the CodePlus survey. A more detailed description of the survey components is provided in Section 6.3.1 and a full copy of the instrument is provided in Appendix C of this document.

The author adopted the instrument used by Sullivan et al. (2015) without further modification for measuring the short-term effects of the intervention. She considers that there are a number of sound justifications, both pragmatic and evidence-based, for this decision. From a practical standpoint, the instrument had been in use by the programme during and following the pilot study and almost two years' worth of data had been collected in this format which could not be disregarded lightly. Moreover, the instrument had been validated through its application in the pilot through content, construct and criterion-related validity. Content validity indicates the extent to which an instrument adequately measures or represents the content of the items that it purports to cover Carmines and Zeller (1979), in this case use of the instrument had been peer-reviewed as had the previous research studies from which it had been developed. Construct validity indicates the extent to which a measurement method accurately represents an abstract construct e.g., a latent variable or phenomena that can't be measured as an actuality, such as a person's attitude or intelligence and produces an observation, distinct from that which is produced by a measure of another construct (Cohen et al., 2007). The study at this stage involved several inherently abstract constructs such as self-efficacy, attitudes and perceptions, the construct validity of which had been assessed with convergent and discriminant techniques (principal component and correlation analysis) in a prior study (Papastergiou, 2008). Finally, criterion-related validity could be assessed if results from later data strongly correlated with the previously-collected data (Cohen et al., 2007).

It is also important to note, that while the instrument remained unchanged, the ways in which the data were analysed for this study varied considerable from that of the pilot study. Interestingly, Papastergiou's instrument was used to measure differences between adolescent girls and boys attitidues, perceptions and motivations towards pursuing academic studies in computer science whilst the CSTY and subsequent CodePlus pilot were concerned with measuring the effect of the intervention on participants by administering a survey pre and post-intervention and comparing results. The CodePlus pliot study also compared the girls' results to a comparable male control group sampled from the ongoing CSTY programme, chiefly for the purposes of baseline comparison. Although components of Papastergiou (2008)'s instrument were used to collect data in the pilot study, no principal component analysis or correlation analysis was performed on the data as per Papastergiou's approach and subsequently this study.

The surveys were taken using the Survey Monkey and Qualtrics[44] survey software packages directly prior to the start of the workshop activities on the first day and directly following the activities on the final day of programme. Data was anonymised and exported to the SPSS software package for analysis, details of the process are given in Section 6.3.1.

5.3.1.2 Longitudinal Survey

Including a longitudinal element in the research design was influenced by the analysis of literature that pointed to a lack of such studies concerning CS outreach for girls (Section 3.7). In a review of the general (male and female) area of CS outreach McGill et al. (2016) had noted a lack of longitudinal research as an issue in fully assessing the impact of programmes. In any study, instant effects may be observable immediately after an intervention, whereas delayed effects occur only after a gestation period (Piesse, Judkins, & Kalton, 2009). Piesse et al. (2009, p. 1) suggest the two main objectives for measuring the effects of an intervention are as follows:

"A need to examine the temporal nature of the effect, whether it is instant or delayed, persistent or temporary", and "to distinguish between confounding variables that causally precede the intervention and mediating variables that are in the causal path between the intervention and the effect. Also, the identification of mediating variables is sometimes an important objective in order to obtain a fuller understanding of the causal process"

The author considered how the longitudinal impact of the intervention could be assessed, against the multifaceted mediating factors that affect college pathway decisions and how identifying these variables would be useful in and of itself. In the context of this study, the participants would typically be making their third level applications two years following participation in the study. Gathering data on whether or not participants had chosen courses related to computer science could provide a significant contribution to this research in this area.

To examine the long-term effects of the intervention on participants, a longitudinal survey was designed by the author to be administered approximately two years following participation in the programme, designed to capture:

1. College course preferences and choices related to CS, computing and related courses.
2. Factors relating to course preferences as perceived by the participant.

[44] From 2018 onwards the survey was moved to the Qualtrics application due to GDPR concerns within the wider organisation in which workshops were run. The survey format was kept intact.

3. CS experience outside of CodePlus in the school and non-formal space. Personal interest in computing, family and other peer influences and other mediating factors that may contribute to a decision to study CS or not.

4. Participants' level of engagement with the CodePlus programme and the impact of CodePlus elements on choosing or not choosing a CS related course.

While the survey was quantitative in nature for the most part with a mixture of likert-style questions and multiple choice options, there were some questions with an option to submit a short open response. Qualtrics survey software was used to host the survey. More detail on the survey design is provided in Chapter 7 and a copy of the instrument is provided in Appendix D of this document.

5.3.2 Qualitative Data

The qualitative data collected in this study includes both handwritten reflective style questionnaires and interview data. The nested nature of these qualitative methods were designed to offer greater insight into the quantitative findings as per the chosen mixed methods model of the study. These approaches and some detail on how data was analysed will be examined below.

5.3.2.1 Reflective Post-Intervention Survey

In addition to the quantitative survey taken pre and post-intervention, participants were invited to complete a short, handwritten reflective-style survey post-intervention. This instrument was designed by the researcher as a supplementary questionnaire to provide additional and contextualised data from participants' perspectives of the intervention through a structured reflection. The reflection consists of a number of open-response prompts to probe student experiences and perspective on the intervention itself. The data from this instrument was transcribed to a digital format for later analysis with Nvivo qualitative analysis software. More detail on the design of the survey is provided in Section 6.3.2 and a copy of the instrument is provided in Appendix E of this document.

5.3.2.2 Interviews

As a widely used and flexible tool for data collection, the interview is a powerful implement for researchers (Cohen et al., 2007). Kvale (1996) considers how the use of interview in research marks a shift from viewing human subjects as "external", and towards the centrality of human interaction for knowledge production through conversations. Where knowledge is constructed between interviewers and interviewees it is neither entirely objective nor subjective but intersubjective (Laing, 1967, p. 66). Through interview, participants are enabled to discuss their interpretations of the world and situations as regarded from their own perspectives.

In the context of this study, the author considered how interviewing a sample of participants who had participated in the intervention and had chosen to pursue a computer science or related pathway in third level education could serve as an explanatory device to further examine the variables and relationships that emerged from the other research methods. As reflected in the design of the longitudinal survey, it was hypothesised that multiple factors contribute to the decision making process for third-level pathways. Accordingly, interviews could help in identifying and isolating the confounding and mediating variables affecting the causal path of the intervention's effect with more veracity than the longitudinal survey alone.

Four individual interviews, each lasting between 30 and 45 minutes in duration were conducted with participants generating roughly 2.25 hours of data. Interviews were conducted and recorded using the video conferencing software Zoom[45]. Video files were converted to a sound file format and transcribed by the author for analysis. More details of the interview procedures and protocols are provided in Chapter 7.

5.3.2.3 Approach to Qualitative Data Analysis

Cohen et al. (2007) summarizes qualitative data analysis as "making sense of the data in terms of the participants' definitions of the situation, noting patterns, themes, categories and regularities". As there is no single or "correct" method of analysing qualitative data, Cohen et al. (2007) advocate that this choice should be guided by a fitness for purpose approach.

Ezzy (2002) describes three key theoretical traditions of qualitative research; grounded theory (Glaser & Strauss, 1967), postmodernism (Derrida, 1976; Foucault, 1977) and hermeneutics (Gadamer, 1975; Heidegger, 1962; Merleau-Ponty, 1962; Ricoeur, 1992). Ezzy (2002) places the tradition of hermeneutics between the extreme alternatives of simple realism and radical postmodern relativism, engaging with the effects of pre-existing theoretical frameworks on data gathering and analysis while still respecting the process of discovery.

In the context of this study, pre-existing theory gathered from a review of theoretical and empirical literature informed the design of initial hypotheses that generated the research questions and determined the course of the investigation. The nested nature of the qualitative data gathered in the short-term phase of the study was intended to both triangulate the quantitative findings and indeed to further explore potential causal relationships between the design elements of the intervention and its effects. Accordingly, directed content analysis (DCA) was deemed the most appropriate strategy for the qualitative analysis of the written survey data.

Regarding the interview data, a less deductive approach was taken with several first cycle coding techniques (Saldaña, 2013) used to analyse the data; holistic and causation coding. There were several reasons for adopting a different analytical approach from that of the written survey data. The units of analysis in the interview data were significantly longer and more descriptive in nature than those of the written reflections, which tended to range from one word to a short paragraph. This enabled the author to consider the meaning of the data in greater context and to begin to establish causes and outcomes from the participants' narratives. While the author considers that this approach was arguably much more grounded in the data than the DCA approach, she does not claim that this approach met the definition of grounded theory as a framework. Rather, in keeping with the view of Cohen et al. (2007) these methods were adopted in the spirit of "fitness for purpose" depending on the nature of the data. Further discussion on the coding and qualitative analysis procedures are provided in Chapters 6 and 7.

[45] It was initially intended that the interviews would take place in person, however government health restrictions necessitated the need to conduct the interviews virtually.

5.3.3 Use of Software in Data Analysis

Both the analysis of quantitative and qualitative data collected in study were supported by software packages. The numerical analysis of data collected was performed using the SPSS software package.

Computer assisted qualitative data analysis software (CAQDAS) provides a powerful and structured way of managing large amounts of text, codes and memos (Gibbs, 2018). While there are numerous features of CAQDAS packages that expedite qualitative analysis procedures, it is important to note that these packages do not analyse the data on their own, but rather provide tools for the researcher in interpreting it. The author was introduced to the Nvivo. CAQDAS through a training course offered at her university and found the software extremely valuable as a tool in managing and analysing the qualitative data in this study. In particular, the retrieval and matrix coding query functions were particularly helpful in making comparisons and building theories.

Gibbs (2018) notes a key issue that concerns researchers in using CAQDAS which is that of feeling distant from the data by comparison to paper-based analysis. In this study, the author spent considerable time reading the handwritten data of participants before transcribing it into an electronic format for analysis in Nvivo. Similarly, the interview files were listened to a number of times before transcription and then printed in hard-copy for reading, re-rereading and initial coding cycles. The author considers that these approaches allowed her to become familiar with the corpus of qualitative data before introducing the software as support.

5.4 Validity and Reliability

Threats to validity and reliability can never be fully removed from a research study, however the effects of these threats can be lessened somewhat with due diligence (Cohen et al., 2007). The principles of validity concerning qualitative and quantitative methods differ greatly; In quantitative data, validity can be improved through careful sampling, appropriate instrumentation and appropriate statistical treatments of the data; ensuring validity in qualitative data is more nuanced in nature and achieved through other means such as richness of the data, extent of triangulation and the objectivity of researcher (Cohen et al., 2007).

Details of measures taken to ensure validity with regard to the short-term survey are provided in Section 5.3.1.1. As the longitudinal survey suffered from significant attrition, its sample size would not accommodate the same power of statistical testing the short-term data could nor was the nature of data suitable for PCA as a measure of internal validity. Nonetheless the sample was of a reasonable size (n=75) for educational research and other statistical anaysis (Cohen et al., 2011, p. 144). The meta-analysis of the all-female outreach offered limited precedents for designing a longitudinal instrument or findings to compare longitudinal results of this study to in terms of content validity, thus the author accepts the design was somewhat experimental in nature and based on her review of theoretical and empirical data. The instrument was designed to harvest specific factual information; the participants' college applications, stated influences, and CS experience outside of the intervention. The author considers it unlikely that participants would be motivated to give responses to these questions that were inaccurate and there was little room for ambiguity in the quantitative nature of the data collected. Categories of factors influencing participants to apply or not to apply for CS related college courses were adapted from a prior study comparing the motivations of male and female students (Papastergiou, 2008), and yielded similar results in further support of the survey data validity. An element of subjectivity arises in the questions bearing on the participants' personal evaluation on the influence of the intervention in subsequent college application choices which is fully acknowledged.

With regard to the qualitative research, the author adopted several of Creswell (2003)'s strategies for validity such as triangulation, rich description, clarification of researcher bias, presentation of negative or discrepant information and prolonged time in the field.

While the concept of reliability as dependability, consistency and replicability may align itself better to the positivist tradition it is still an important element of qualitative research (Cohen et al., 2007). Lincoln and Guba (1985) suggest that in naturalistic inquiry the term reliability can be supplanted with terms such as "credibility", "consistency", "trustworthiness" and "dependability".

The reflective style questionnaires and the interviews provided an opportunity to hear the authentic voice of the participants and their views on how the intervention affected them. The consistency of themes emergent in the questionnaire data and richness of the interview narratives provided a valuable insight into the impact of the intervention.

5.5 Ethics

It is prudent for a researcher to anticipate the ethical issues that may arise during the course of a study. While ethical considerations are manifold, issues arise primarily in specifying the research problem, identifying a purpose statement and research questions, and collecting, analysing, and writing up the results of the data (Creswell, 2003).

In identifying a research problem, it is important to consider how studying this problem will benefit the individuals being studied. In the context of this study the intervention was intended to serve as a positive experience for participants to help them make an “informed decision” regarding third level computer science. While it was unlikely that all participants would leave the intervention with a high level of enthusiasm for computer science, the workshop was framed as an opportunity to explore this pathway for a few days outside of the school environment. Participants were reassured at the outset of workshops that having a greater, lesser or an unchanged level of interest towards computer science were all equally valid outcomes following participation in the programme. Similarly, as the purpose of the study was to investigate the intervention’s effects and design, the participants and parents/guardians were fully informed of the purpose of study in writing and with additionally with a verbal briefing session for participants on the first day of the intervention.

With regard to data collection, participation in all or part of the research study was voluntary, the right to withdraw at any time was upheld and participants were encouraged to ask questions if they needed clarification. The anonymity of individual participants was protected by disassociating names from responses in the survey data and by assigning pseudonyms to names given in the interview data.

Thee research approach and method in this study complies with the ethical requirements of Trinity College Dublin and its school of Computer Science and Statistics for which approval was granted. Student and parental permission was obtained for participation both in the workshops and in the attendant research. Copies of relevant consent forms are provided in Appendix F of this document.

5.6 Chapter Summary

The methodological approach and rationale is influenced both by the purpose of the study and by the personal knowledge claims held by the researcher. This study was inherently pragmatic in its nature with a mixed method framework taking aspects of both the quantitative and qualitative traditions. Three distinctive mixed method strategies were considered and conceptualised by the author, the chosen model reflecting the nested nature of the data collection and the longitudinal nature of the study. This strategy was intended to answer both the "what" in terms of the measurable variables of the intervention effects, whereas supplementary qualitative data could answer the "how".

The particular instruments that were adopted and designed for use during the study were presented with details for how data would be analysed. The following chapters 6 and 7 will present the results of these analyses and discuss the author's findings.

6 Short-term Data Findings and Analysis

6.1 Introduction

The review of theoretical, empirical, and policy based literature relevant to the central phenomenon (presented in Chapters 2 and 3) informed both the design elements of the intervention and the research methodology (Chapters 4 and 5). The mixed-methods, concurrent-nested design strategy was designed with both a short-term and a longitudinal element.

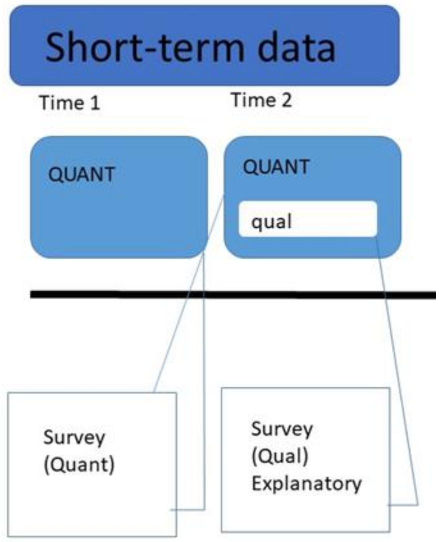


Figure 20: Short-term data diagram illustrating nested mixed methods design

This chapter describes the utilization of tools, processes of data analysis, and findings from the short-term stage of the data analysis. A quantitative lead was employed using a validated pre and post-intervention tool to measure key attititudinal and intentional variables pertaining to the central phenomenon of girls' interest (or lack therof) in computer science pathways. The concurrently collected qualitiative data was intended to serve two functions; to futher validate and triangulate the findings of the quantitative data, and to offer a deeper, explanatory inspection of those findings. These findings would in turn inform the design of the longitudinal element of the research design.

6.2 Research Aims and Questions

The research aims specific to the short-term element of the study were:

1. To assess the short-term impact of the intervention
2. To gather and analyse data on role of pedagogy in the design
3. To determine other principal aspects of the of the intervention that may contribute to improving key attitudinal and intentional variables
4. To develop a structured framework for assessing the short-term impact of computer science outreach programmes for girls
5. To generate relevant questions for future research

Based on the identification in the literature of key contributory factors to gender imbalance, and strategies to address said imbalance, it was hypothesized that the design elements of the intervention would affect positive change in the short-term. Nonetheless, prior to the execution of the intervention and relevant data collection it was not possible to be sure if the intervention would affect change (either positive or negative), nor if these changes could be attributed to the design elements of the intervention. To that end, the research questions concerning the short-term element of the research were reasonably broad with regard to offering a focus for the analysis and discussion of findings:

Research Question 1: What is the short-term effect of the intervention's approach?

Research Question 3: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term change?

Each research question can be further expanded to guide the analysis. With regard to RQ1:

a) Did the intervention affect significant short-term changes in key-attitudinal variables such as computer self-efficacy and perceptions of CS?
b) Did the intervention affect significant short-term changes in intentional variables such as careers and college pathways?
c) What were the significant relationships between the measured variables?

These sub-questions could be posed given the quantitative, prescriptive nature of the data collected and the subsequent suitability of such data for statistical analysis techniques.

With regard to RQ3, the qualitative, rich textual data collected enabled the researcher to either confirm or to contradict the findings of the quantitative data and explore a set of sub-questions thus:

a) How did the pedagogical design aspects of the intervention affect short-term outcomes?
b) How did other design aspects of the intervention (all-female environment, college location etc.) affect short-term outcomes?
c) Are there other factors emergent in the data that contribute to girls' predilections towards (or away from) career and college pathways in computer science?

6.3 Data Collection and Analysis

The short-term element of the research took a mixed methods approach with a quantitative lead. In this approach, a pre-experimental design was first used to quantify the intervention's impact on participants' key attitudinal and intentional variables (Creswell, 2009). The author wishes to acknowledge at this point that much of the quantitative, short-term data collected and analysed in this chapter was previously published in the research journal ACM Transactions on Computing Education (G. Lawlor et al., 2020). She fully acknowledges the contributions of her colleagues Mr. Philip Byrne and Professor Brendan Tangney as co-authors and cites the paper where its findings are presented in this chapter.

The nested, qualitative data was used to triangulate the findings of the qualitative data, in an explanatory capacity, whilst also offering an opportunity to explore and uncover emergent themes. Directed content analysis techniques were employed to analyse the qualitative data collected at this stage of the research.

6.3.1 Pre-Experimental Data Collection and Analysis

A pre and post-intervention survey measuring key attitudinal and intentional variables pertaining to the central phenomenon under investigation was administered to the participants to generate quantitative data.

In summary, the survey consisted of six distinctive groups of questions:

1. **Demographic Information**
   This consisted of biographical information such as name, age, and school name. This information would be used to identify students and match the pre and post-intervention surveys for statistical analysis of variables. Data could also be categorised by school, allowing a means to check for related variance.

2. **Mathematics and Computer Use**
   Participants were asked to submit their actual or predicted maths grades for the Junior Cycle State Examinations and indicate their access to, and use of, computers. The rationale for including an option to submit expected grades was due to the timing of the intervention for some participants when results would not yet have been released. The majority of participants would have received their actual grades by this stage and in any event, those who had not yet would have received a "mock" grade from their school as a baseline estimate.

3. **Computer and Programming Self-Efficacy**
   This section used a slightly modified version (Sullivan et al., 2015) of a validated instrument used to measure computer self-efficacy (Papastergiou, 2008). Participants were asked to state their level of agreement on a 5-point scale (from "strongly disagree" to "strongly agree") with 10 self-efficacy statements concerning computer programming. Participants were also asked to rate their programming ability in general and their level of knowledge concerning a number of common programming languages.

4. **Third Level Intentions**
   Participants were asked to indicate how likely it was that they would attend third level education (in general terms), how confident they were to be accepted to third level and the

same set of questions concerning computer science related courses. Participants were also asked to indicate how suitable various university subjects would be for them on a 5-point scale (very good to bad).

5. **Perceptions of Careers and College CS**
   Questions that explored students' perceptions of college and careers in CS were adapted for use in this survey (Sullivan et al., 2015) from a validated instrument to measure perceptions of "CS and the IT profession" (Papastergiou, 2008). These presented 9 specific areas of CS to the students and asked them to rate on a 5-point scale (1: not at all, 5: to a very large degree) the extent to which they believed that a CS college course involved the specific area; "Doing a lot of mathematics, spending a lot of time programming, learning different programming languages, working in groups, being creative, solving problems, learning how to communicate, designing computer games, spending a year abroad". It also asked them to rate on the same 5-point scale the extent to which they believed that the IT profession involved each of 8 aspects: "Doing a lot of mathematics, spending a lot of time programming, learning different programming languages, working in groups, being creative, solving problems, learning how to communicate, designing computer games, spending a year abroad".

6. **Gender perceptions, Stereotypes and Personal Belief Statements**
   A final suite questions asked participants to express their opinions by indicating on a 5-point scale (strongly disagree to strongly agree) their level of agreement with 30 statements. The statements concerned the suitability of CS and the IT profession for men and women, stereotypical views of computer science e.g.: "Computer science is for geeks", "Computer science is for nerds", and a number of personal belief statements concerning computer science e.g.: "Programming will not be important to me in my life's work", "Knowing programming will help me earn a living". The gender-based questions were adapted from Papastergiou (2008) who in turn had referenced prior research in their construction of the set (Craig et al., 2002; Galpin & Sanders, 2002; Moorman & Johnson, 2003).

Creswell (2003, p. 168) defines a "One-Group Pretest-Postest Design" as an example of a Pre-Experimental Design whereby a pre-test measure is followed by a treatment and a post-test for a single group. With pre-experimental designs, the researcher studies a single group and provides an intervention during the experiment. A potential threat to the validity of the study is that this model does not have a control group to compare with the experimental group (Creswell, 2003), however given the nature of the study as a functioning outreach programme, creating a control group as in a quasi or true experiment was deemed to be neither practical or appropriate.

Participation in the research component of the CodePlus intervention was voluntary e.g.: students were welcome to attend the workshop activities either way, and the right of participants to refuse or withdraw their surveys was upheld without penalty[46]. From a cohort of 1,032 programme participants recorded between 2015 and 2020, 898 students completed a pre-intervention survey, 873 completed a post-workshop survey, and 856 participants completed both.

Data collected through the administration of the survey (n = 856) was analysed in the following ways:

[46] For details of the procedures put in place to ensure the ethical handling of student data, debriefing arrangements, and means for withdrawing data please see Methodology Chapter 4.

- Summary and descriptive statistics (Means, frequencies, standard deviation).
- Paired sample t-tests were run to determine whether there were significant differences observed between pre and post-intervention data concerning perceptions of CS, computer self-efficacy, and intentions to study undergraduate CS.
- To increase understanding of the underlying factor structure of participants' perceptions of the IT profession and undergraduate CS, a principal component analysis (PCA) was run on the relevant data.
- To access the relationship between participants' computer self-efficacy and intentions to study undergraduate CS, a Spearman's rank-order correlation was run.

The findings from the survey will now be presented by the aforementioned survey categories

1. **Demographic Information**

The participants could be categorised by 55 individual schools, largely concentrated in the greater Dublin area with a small number of exceptions[47]. The mean age of participants was 15.3 (SD=.94).

281 (33.8%) of participants (N=832) indicated that they either "strongly agreed" or "agreed" with the statement: "I have a friend or family member in the Computer Science industry" in the pre-intervention survey.

234 (27.9%) of participants (N=840) indicated that they either "strongly agreed" or "agreed" with the statement: "I know a successful person that has a Computer Science related degree".

262 (31.3%) participants (N=836) indicated that they either "strongly agreed" or "agreed" with the statement: "I know someone with a Computer Science degree".

2. **Mathematics and Computer Use**

Table 9 below presents a breakdown of participants who indicated taking Higher, Ordinary, or Foundation Level Mathematics and the percentages of whom who had achieved or expected to receive a C grade or higher.

A majority of 599 students indicted that they were had taken higher level mathematics in the Junior Cycle State Examinations with 87% of that cohort indicating an actual or predicted C grade or higher.

Level	**N (participants)**	**Percentage indicating a C grade or higher in actual or expected Junior Certificate grades**
Higher	599	87%
Ordinary	205	91.7%
Foundation	26	92%

Table 9: Breakdown of JC Mathematics Level Taken and Actual or Expected Grades

[47] Details on the selection criteria for schools is provided in Chapter 5 Implementation

This is an interesting baseline finding given the considerable literature that links mathematical-efficacy and interest in CS career pathways (Beyer et al., 2003; Ceci & Williams, 2009; Dickhäuser & Stiensmeier-Pelster, 2003). A C grade or higher at the higher level[48] (in Leaving Certificate State Examinations) has typically been one of the entry criterion for undergraduate computer science and related degree courses. Accordingly, while taking higher level mathematics at the Junior Cycle stage is not a mandatory pre-requisite, it is generally a key indicator of which students will progress to the higher level in the Senior Cycle classes. While these data indicate a reasonable level of mathematical competence within the cohort, the author cautions that this may be in part due to the selection criteria of teachers over which she had no control. That is to say that this sample may not be fully representative of the wider population of adolescent female students and that teachers may have and purposefully (and understandably) selected students from the higher level classes for participation in the programme.

In terms of access to computer use, 94% of respondents to the question (n=854) indicated that they had access to a home computer (desktop, laptop or tablet device). 55% of respondents (n=810) indicated that their home computer was for shared use while 45% indicated sole use. This supports findings in the literature that report few gender differences in western countries in terms of access to devices (Ofcom, 2015), and gives cause to revisit and reconsider what was once a key area of research on the central phenomenon (Bartol & Aspray, 2006; Klawe, 2002; Margolis & Fisher, 2002; Spertus, 1991).

A further baseline measure of the participants' computer usage was taken, categorised by common software applications listed in Table 10 below. Participants were asked to rate on a 5-point scale (1=never, 5=10 hours or more), how often they used that software in an average week. Email, word-processing, presentation software and multimedia applications were reported as having the highest mean usage while web-authoring, databases and spreadsheets had the lowest.

Type of Software Usage	**n**	**Mean**	**Std. Deviation**
Word Processing	845	**2.50**	.810
Email	847	**2.39**	.717
Presentation Software	820	**2.14**	.792
Spreadsheets	841	**1.31**	.603
Database	825	**1.20**	.508
Web-authoring	835	**1.27**	.586
Multimedia Application	848	**2.06**	.976

Table 10: Participants' Software Application Usage

A second set of questions on computer usage was asked with a similar format whereby participants were asked to rate on a 5-point scale (1=never, 5=10 hours or more), how often they used computers for particular tasks in an average week. This data is presented in Table 11 below:

[48] Since the time of data collection and analysis the grading scheme for the Irish State Examinations has changed http://transition.ie/files/2015/Full%20Details%20-%20Revised%20Common%20Points%20Scale.pdf

Activity	**n**	**Mean**	**Std. Deviation**
Homework	854	2.26	.945
Searching for information (not homework related)	846	2.28	.913
Developing Websites	847	1.19	.542
Writing Computer Programs	846	1.12	.449

Table 11: Time spent using computers on activities

Doing homework and searching for information online were reported to have the highest mean usage while developing websites and writing computer programmes had the lowest means. Based on prior applications of the instrument (Sullivan et al., 2015; Tangney et al., 2009), these findings would suggest reasonable baseline levels of computer literacy in participants', although certainly less so in terms of the more technical applications (web-development, spreadsheets, programming).

3. Computer and Programming Self-Efficacy

Paired sample t-tests were run to determine whether there were differences in scores between pre and post-intervention on a modified computer self-efficacy (MCSE) scale. These scores were calculated for each participant based on the approach of previous researchers (Eachus & Cassidy, 1996; Papastergiou, 2008) with possible individual scores of 10-50, the higher value indicating higher levels of computer self-efficacy. A statistically significant increase was found between the observed pre-workshop MCSE mean scores (31.65) and post-workshop mean scores (34.13),$t(609) = 13.034$, $p < 0.001$, CI.95 2.105, 2.852. A medium effect size was observed ($d = 0.53$).

To assess the relationship between MCSE and participants' self-reported intentions to study a CS degree (on a scale of 1-5, 1=strongly disagree, 5= strongly agree), a Spearman's rank-order correlation was run. Visual inspection of a scatterplot (Figure 21) suggested a monotonic relationship between the variables, a key assumption of this test. A statistically significant moderate positive correlation between MCSE and participants' self-reported intentions to study a CS degree was observed, $r_s(619) = 0.401$, $p < 0.001$, indicating an association.

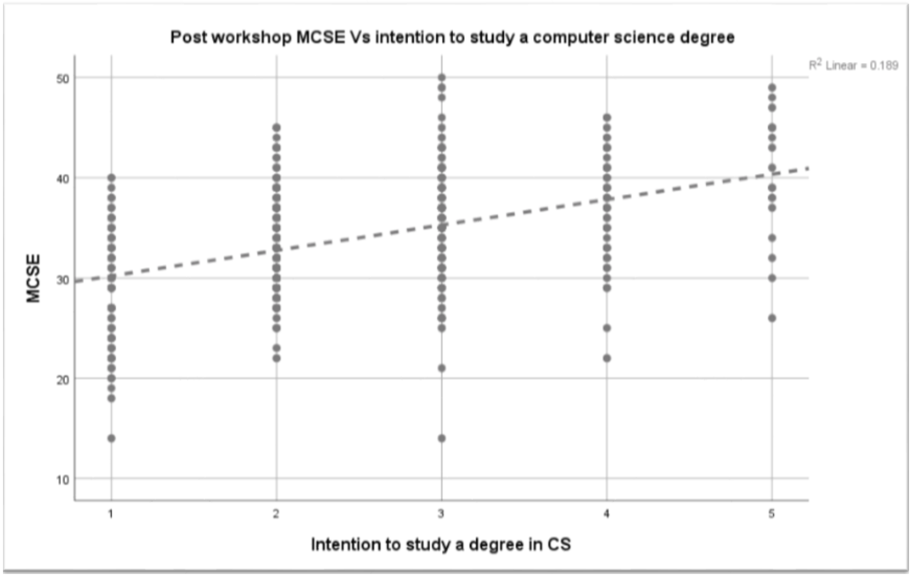


Figure 21: MCSE score vs. intention to study a computer science degree (G. Lawlor et al., 2020)

Paired sample t-tests were run to determine if participants' self-reported levels of programming knowledge and ability changed significantly following participation in the workshops. Participants were asked to rate their programming ability on a Likert scale (1=very poor, 5=excellent). A statistically significant increase was found between the pre-workshop survey (2.73) and post-workshop survey (3.36) mean scores, t(689) = 20.129, $p < 0.001$, CI.95 0.570, 0.694. A medium effect size was observed (d = 0.77). Significant increases were also observed when participants were asked to indicate their levels of programming knowledge (1=none, 5=very high) pre and post-workshop concerning the specific programming languages Scratch and Python (see Table 12 below), the other programming languages surveyed returned insignificant results in the paired-tests which is to be expected given that Scratch and Python were the primary programming languages used during the workshops.

Programming Language	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
Scratch	2.27	1.248	3.68	.990	-27.915 (676)	.000	1.07
Python	1.23	.604	1.86	1.045	-15.716 (670)	.000	.6

Table 12: Paired t-test results for self-reported programming knowledge(G. Lawlor et al., 2020)

4. Third Level Intentions

Paired sample t-tests were run to determine if participants' self-reported levels of intention to study undergraduate CS changed significantly post-intervention. Table 13 illustrates the increases found from the pre-workshop to post-workshop survey mean scores when participants were asked to indicate on a Likert scale (1=strongly disagree, 5= strongly agree) their level of agreement with the statements "I intend to do a degree in computer science" and "I would like to do a degree in computer science."

The author considers the subtle difference between the two statements in that "I intend..." is a statement indicating a stronger commitment than "I would like to....".

Intent Statement	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
"I intend to do a degree in Computer Science"	2.36	.916	2.53	.920	4.908 (653)	.000	0.2
"I would like to do a degree in Computer Science"	2.67	.995	2.88	1.025	6.273 (662)	.000	.24

Table 13: Results of Paired t-Tests for Future Intentions with CS Degrees (G. Lawlor et al., 2020)

Participants were asked to indicate how good a choice a selection of ten broad university subjects (Environmental Science, Economics, Communications Studies, Engineering, Biology Biological Sciences, Education, Psychology, Computing/Computer Science/Information Technology, Design (CCSIT), Business / Management / Marketing) would be for them on a scale of bad (1) to very good (5). A statistically significant increase (with small effect sizes) was found between the observed pre and post-intervention means in three subject areas; CCSIT, Engineering, and Communications Studies, these are presented in Table 14 below:

Subject Area	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
CCSIT	2.99	.04349	3.15	.04296	4.334 (669)	.000	0.16
Engineering	2.82	1.24087	2.92	1.20790	3.066 (675)	.002	0.12
Communications Studies	3.07	1.04765	3.17	1.11738	-2.468 (669)	.014	0.10

Table 14: T-test results of participants rating of suitability of university subjects(G. Lawlor et al., 2020)

Participants were also asked to indicate how confident they felt to be accepted to study a CS-related course on a scale of not at all confident (1) to very confident (5). A statistically significant increase was found between the observed pre-workshop mean (2.96) and post-workshop mean (3.20), $t(672) = 6.549$, $p < 0.001$, CI.95 0.16854, 0.31288. A small effect size was observed ($d = 0.25$).

5. Perceptions of Careers and College CS

Participants indicated on a Likert scale to what degree they believed the CS profession involved particular characteristics (1 = not at all, 5 = to a large degree). Three items were reverse coded prior to running this analysis: is difficult, involves doing a lot of mathematics, demands that one engages in computer programming. In keeping with the approach of Papastergiou (2008) and to better understand the underlying factors present, a PCA was run on the 12 variables used to measure a participant's perception of the IT profession.

The KMO's Measure of Sampling Adequacy was 0.87, which can be deemed "good" (Kaiser & Rice, 1974). The Bartlett's Test of Sphericity was significant, $p < 0.001$. These combined results support the approach of using PCA for this set of variables. Factors were extracted based on eigenvalues greater than 1. A three-factor structure was produced based on this parameter as illustrated in Table 7. The first factor, named "Various Advantages in the IT Profession" contained the same six items as found in the factor named in Papastergiou's study as "Various Advantages." This factor explained 37.54% of the variance in perception scores. It was found that factor 2 contained three of the variables added to the survey by the authors and was named "Variety and Utility of the IT Profession"; factor 2 explained 10.85% of the variance. The third factor named "Ease and Disassociation from Programming and Maths" contained the same three items as the second factor found in Papastergiou's study and explained 8.92% of the variance.

A varimax rotation was applied to allow for better interpretation of these factors (see Table 15). This rotated solution explained 57.3% of the variance across responses to the set of questions regarding perceptions of the IT profession. Pre-workshop and post-workshop mean scores were calculated for each factor and compared using paired sample t-tests. The results of these tests are presented in Table 16.

Aspects	Factor		
	1	2	3
Is well paid	.732		
Is prestigious	.716		
Is interesting	.655		
Offers the opportunity to engage in a variety of fields	.626		
Is creative	.561		
Is competitive	.428		
Involves working in a team		.779	
Involves problem solving		.764	
Involves being useful to other people		.687	
Is not difficult			.772
Does not involve doing a lot of mathematics			.692
Does not demand computer programming			.476
% of variance explained	37.54%	10.85%	8.92%

Table 15: Results of PCA on Perceptions of the IT Profession(G. Lawlor et al., 2020)

Factor	Pre-workshop		Post-workshop		t-test statistics		Effect Size
	M	*SD*	*M*	*SD*	*t(514)*	*p*	*d*
Various Advantages in IT	3.4	.57	3.62	.62	9.151	.000	.4
Variety and Utility of IT Profession	3.79	.76	3.96	.68	4.917	.000	.22
Ease and dissociation from programming and maths	2.46	.67	2.55	.63	2.796	.005	.12

Table 16 : T-test results of Perceptions of IT Profession Factors(G. Lawlor et al., 2020)

To understand the underlying structure of the eight variables measuring perceptions of CS undergraduate courses, a second PCA was run. Participants indicated their levels of agreement on a Likert scale with a number of statements related to perceptions of CS degrees (1=strongly agree, 5=strongly disagree). Five items were reverse coded prior to running this analysis: learning how to communicate, being creative, working in groups, solving problems, and spending a year abroad.

The KMO's Measure of Sampling Adequacy was 0.747 (good) and the Barlett's test of sphericity was significant, $p < 0.001$. A two-factor structure based on eigenvalues greater than 1 was extracted, named "Variety and Advantages of CS Degree", and "Disassociation from Programming and Mathematics" the details of which are presented in Table 17. Pre- and post-workshop mean scores were calculated for each factor and they were compared using paired sample t-tests. The results of these tests are presented in Table 18.

Aspects	Factor	
	1	2
Learning how to communicate	.790	
Being creative	.761	
Working in groups	.722	
Solving problems	.640	
Spending a year abroad	.454	
Spending a lot of time programming		.832
Learning different programming languages		.775
Doing a lot of mathematics		.585
% of variance explained	34.36%	18.82%

Table 17: Results of PCA on Perceptions of CS Undergraduate Course Factors (G. Lawlor et al., 2020)

Factor	Pre-workshop		Post-workshop		t-test statistics		Effect Size
	M	*SD*	*M*	*SD*	*t(563)*	*p*	*d*
Variety and Advantages of CS Degree	3.89	.53	4.01	.49	5.502	.000	.23
Dissociation from programming and maths	2.00	.53	2.13	.61	4.898	.005	.21

Table 18: T-test Results of Perceptions of CS undergraduate Course Factors (G. Lawlor et al., 2020)

6. Gender perceptions, Stereotypes and Personal Belief Statements

The final set of questions asked participants to express their opinions by indicating on a 5-point scale (strongly disagree to strongly agree) their level of agreement with 30[49] statements. In the three statements that related to gender perceptions of Computer Science;

"Computer Science is a science more appropriate for men than for women"

"Men are more likely to succeed in the IT profession than women"

"Men are by nature more inclined towards Computer Science than women"

All mean scores reported were lower post-intervention (indicating stronger levels of disagreement), however paired t-tests returned just one significant result at the 95% level of significance for the statement "Men are more likely to succeed in the IT profession than women" between the observed pre-intervention mean (1.92) and post-workshop mean (1.83), $t(673) = 2.569$, $p < 0.005$, CI.95 .021, .157. A small effect size was observed ($d = 0.10$).

[49] There were a number of duplicates in this set of questions from earlier questions in the survey which the author discarded. Thus, not all results on statements are reported. A copy of the survey is provided in the appendices.

In the three statements that related to perceptions of Computer Science involving programming;

"Computer Science involves mainly programming"

"Computer Science degrees deal mostly with programming"

"Programming is closely related to Computer Science"

Paired t-tests returned no significant results at the 95% level of significance.

In the three statements relating to stereotypes;

"When I think of Computer Science degrees I think of geeks"

"When I think of Computer Science degrees I think of nerds"

"Computer Science is for geeks and nerds"

Paired t-tests returned significantly lower mean scores (indicating a higher level of disagreement) with the statements; "When I think of Computer Science degrees I think of geeks", "When I think of Computer Science degrees I think of nerds". Table 19 below presents these results. Small to median effect sizes are reported.

Statement	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
"When I think of Computer Science degrees I think of geeks"	2.59	1.169	2.23	1.076	9.511 (660)	.000	.37
"When I think of Computer Science degrees I think of nerds"	2.56	1.151	2.21	1.062	9.098 (672)	.000	.35

Table 19: T-test Results for Statements on Stereotypes (G. Lawlor et al., 2020)

Baseline measures of participant's prior experience of knowing friends, family or others working in the computer industry or holding a computer science degree were reported on in the demographic results. Accordingly, differences in response to two statements:

"I know a successful person that has a Computer Science related degree"

"I know someone with a Computer Science degree"

were examined from pre to post-intervention using paired t-tests. Significantly higher mean scores were reported (indicating a higher level of agreement) with both statements. Table 20 below presents these results. Small effect sizes are reported.

Statement	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
"I know a successful person that has a Computer Science related degree"	2.62	1.329	2.85	1.358	4.956 (670)	.000	.19
"I know someone with a Computer Science degree"	2.68	1.352	2.86	1.370	4.066 (664)	.000	.16

Table 20: T-test Results on Statements Knowing People with CS degrees (G. Lawlor et al., 2020)

12 Personal intent statements regarding programming and computer science could be spilt as "positive" and "negative". The 6 positive statements were thus:

"I'll need programming for my future work"

"I study programming because I know how useful it is"

"Knowing programming will help me earn a living"

"Computer science is a worthwhile and necessary subject"

"I'll need a firm mastery of programming for my future work."

"I will use programming in many ways throughout my life"

Paired t-tests returned significantly higher mean scores for three statements (indicating a higher level of agreement). Table 21 below presents these results. Small effect sizes were reported.

Statement	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen's d**
"I'll need programming for my future work"	2.84	.951	2.94	.956	2.740 (663)	.006	0.1
"I study programming because I know how useful it is"	3.08	1.010	3.19	1.016	2.813 (664)	.005	0.1
"Knowing programming will help me earn a living"	3.18	.963	3.28	.980	2.624 (661)	.009	0.1

Table 21: T-test Results of Positive Personal CS Statements(G. Lawlor et al., 2020)

The 6 negative statements were thus:

“Programming is of no relevance to my life.”

“Programming will not be important to me in my life's work”

“I see computer science as a subject I will rarely use in my daily life”

“Taking computer science courses is a waste of time”

“In terms of my adult life it is not important for me to do well in computer science in college.”

“I expect to have little use for programming when I get out of school”

Paired t-tests returned significantly lower mean scores for two statements (indicating a higher level of disagreement). Table 22 below presents these results. Small effect sizes were reported:

Statement	***Pre-Workshop***		***Post-Workshop***		***T-test statistics***		**Effect Size**
	M	***SD***	***M***	***SD***	***t (df)***	***p***	**Cohen’s d**
“I see computer science as a subject I will rarely use in my daily life”	2.68	1.038	2.56	.983	2.700 (659)	.007	0.1
“I expect to have little use for programming when I get out of school”	2.75	1.017	2.63	1.055	2.635 (663)	.009	0.1

Table 22: T-test Results of Negative Personal CS Statements (G. Lawlor et al., 2020)

The results of the quantitative analysis presented strongly support the hypotheses that the intervention would affect positive change in the short-term across key attitudinal and intentional variables. A discussion on these results is provided at the end of this chapter.

The following section will present the details of collection, analysis, and findings from the qualitative data.

6.3.2 Qualitative Data Collection and Analysis

In addition to the quantitative survey taken pre and post-intervention. Participants were invited to complete a short, handwritten reflective-style survey post-intervention with a mix of open and closed questions[50]. Open question responses gathered in this survey yielded qualitative data with two open responses following a closed prompt question;

1. Overall, how would you rate your experience at the CodePlus programme?

(Excellent, Good, Average, Fair, Poor)

Why do you feel this way?

2. Would you be interested in participating in other Coding workshops with this project during the year?

(Yes, No)

Please explain your decision.

Participants were then prompted to write:

3. Three things I learned about myself and how I learn during the programme

4. Any other comments or suggestions to improve the programme?

This reflective survey style keeps with the approach of previous Bridge21 activity evaluations (Bray & Tangney, 2016; Conneely et al., 2015; J. Lawlor et al., 2016). Social science researchers have noted that the medium in which a researcher gathers data may affect the data gathered (Babbie, 2020) and the author considers several important differences between this survey and the pre-experimental survey. Foremost, the pre-experimental surveys were taken via computer using the Survey Monkey and Qualtrics survey software packages and exclusively consisted of closed variable data. The qualitative, post-intervention instrument was framed as an opportunity for the students to take a one-page print-out and to reflect on their experience at the end of the workshop. The handwritten survey was also considerably shorter in length than the computer-based and by its nature more opinion-based than the latter. The author considers that to this end the handwritten survey was viewed as an evaluation tool in which the participants had agency to openly comment on their experiences and indeed suggest improvements or changes to the programme. To hypothesise whether using a paper based survey (as opposed to allowing for open comments on the computer-based survey) would yield different or more favourable qualitative data is outside the parameters of this study, nonetheless the author considers the relevant arguments made for both sides in a review of studies on computer vs paper studies (Hayslett & Wildemuth, 2004). In the context of this study, the author defends the

[50] This data is separate to that which was collected and analysed in the co-authored research paper (G. Lawlor et al., 2020) with the instrument designed solely by the author of this thesis.

decision to keep the paper-based instrument separate in its usage as it was intended for a distinctively separate purpose than that of the computer-based pre-experimental survey.

The rationale for including the aforementioned open questions were as follows

1. To gather rich, textual data on how the participants viewed their experience of the workshops (intervention).
2. To ascertain if and why the participants would be interested in attending further computing workshops with the programme.
3. To encourage the participants to reflect on their learning within a learning context that is "grounded in metacognition", and to capture that metacognition (Tanner, 2012).

The survey also served a pragmatic purpose in that participants could indicate whether or not they would be interested in participating in further workshops with the CodePlus programme[51] (and give a rationale to be considered for selection).

Yin (2014) describes such documents as corroboratory data, suggesting that they may provide records of events that were unobservable, but are rarely however without bias, as they are written with a particular audience in mind (in this case the programme facilitators). With this in mind, several measures were put in place to reduce bias. The participants of each workshop were encouraged to be honest in their responses and reassured that any negative reports or comments would not "hurt anyone's feelings" on the part of the team, also students were instructed to spread out in the learning space and find some personal space to write on the survey to provide a greater degree of privacy and atmosphere conducive to reflection.

The handwritten survey was designed and introduced by the author for use in the programme from 2017 onwards. A total of 418 surveys were collected between 2017 and 2020 and transcribed to Microsoft Excel for storage and preliminary analysis.

6.3.2.1 Directed Content Analysis

Content analysis can be characterised as when deductively derived theory and deductively driven data analysis work "down" from pre-existing theoretical understandings (Glaser & Strauss, 1967). Pre-existing theory is used to develop categories of analysis through logical deduction and tested against empirical data (Ezzy, 2002).

Given the nested nature of the qualitative data used in this stage of the study, directed content analysis (DCA), was deemed as the most appropriate strategy to use. A detailed justification for choosing DCA is provided in Section 5.3.2.3. Ezzy (2002) writes that content analysis involves first defining units of analysis and the categories into which these will be placed, each unit of analysis is then reviewed and categorised according to the predefined categories. Occurrences of categories and codes are then counted and comparisons made, often using quantitative methods (Ezzy, 2002).

The fundamental aspects of content analysis can be summarized thus:

1. Identify categories prior to searching for them in the data.

[51] Opportunities to return for additional computing workshops and camps were facilitated each year for a limited number of students. While a rigorous evaluation of the effect of attending returning workshops is outside the scope of the short-term study, the question is included in the longitudinal component.

2. Select the sample to be categorised and identify units of analysis.
3. Count, or systematically log, the number of times the categories occur. (Kellehear, 2020)

While contending that content analysis is a helpful method to confirm or test pre-existing theory, Ezzy (2002) cautions that this comes at a cost of restricting the extent to which the data will "speak" to the researcher. To that end, he notes that content analysis is often combined with more inductive methods that allow for emergent categories and interpretations. While the author's strategy at this stage of the study leaned heavily towards a directed approach, a number of themes and codes did emerge inductively throughout the process of analysis and were included in the final coding schema. The author considers that this practice was akin to thematic analysis whereby general issues and themes are determined prior to analysis, but the form of research may uncover unanticipated issues induced from data (Ezzy, 2002).

In order to conduct deductive (directed) content analysis, the first step is to develop a categorisation matrix (Elo & Kyngäs, 2008). A categorisation matrix is generally based on earlier work such as literature reviews, theories and models (Hsieh & Shannon, 2005; Polit & Beck, 2004; Sandelowski, 1995). At this stage of the study two distinctive categorisation matrices were developed. The first based on the key attitudinal and intentional variables derived from the literature and the quantitative instrument used, affecting girls' predilections towards computer science pathways (Effects), the second based on the design considered elements of the intervention (Intervention Design).

Based on the approach of Elo and Kyngäs (2008), Figure 22 and Figure 23 illustrate the coding matrices used for the Effects and Intervention design directed coding respectively. In the Effects (main category) matrix, the generic categories were as follows: self-efficacy, perceptions of CS, future intentions. The subcategories break down each generic category into 22 smaller codes.

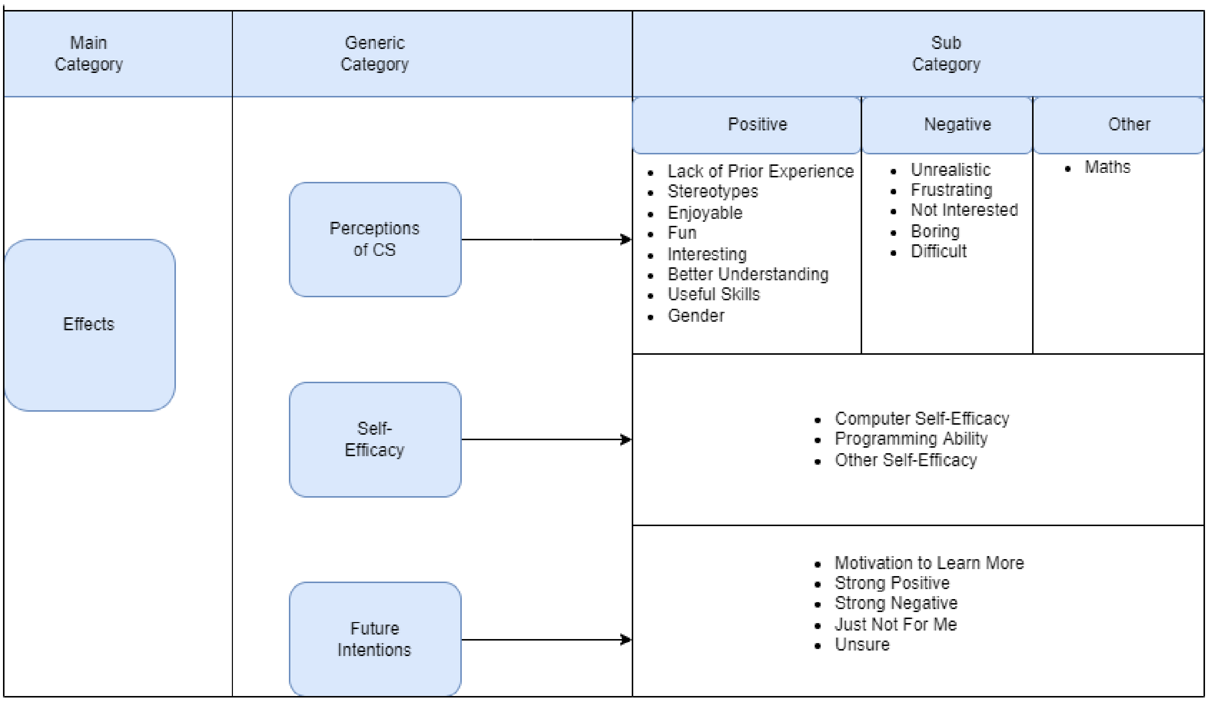


Figure 22: Effects Categorisation Matrix

In the 2nd matrix, Intervention Design (main category), the generic categories were as follows: pedagogical approach, technology used, all-female environment and improvements. Again, the subcategories break down each generic category into 23 smaller codes.

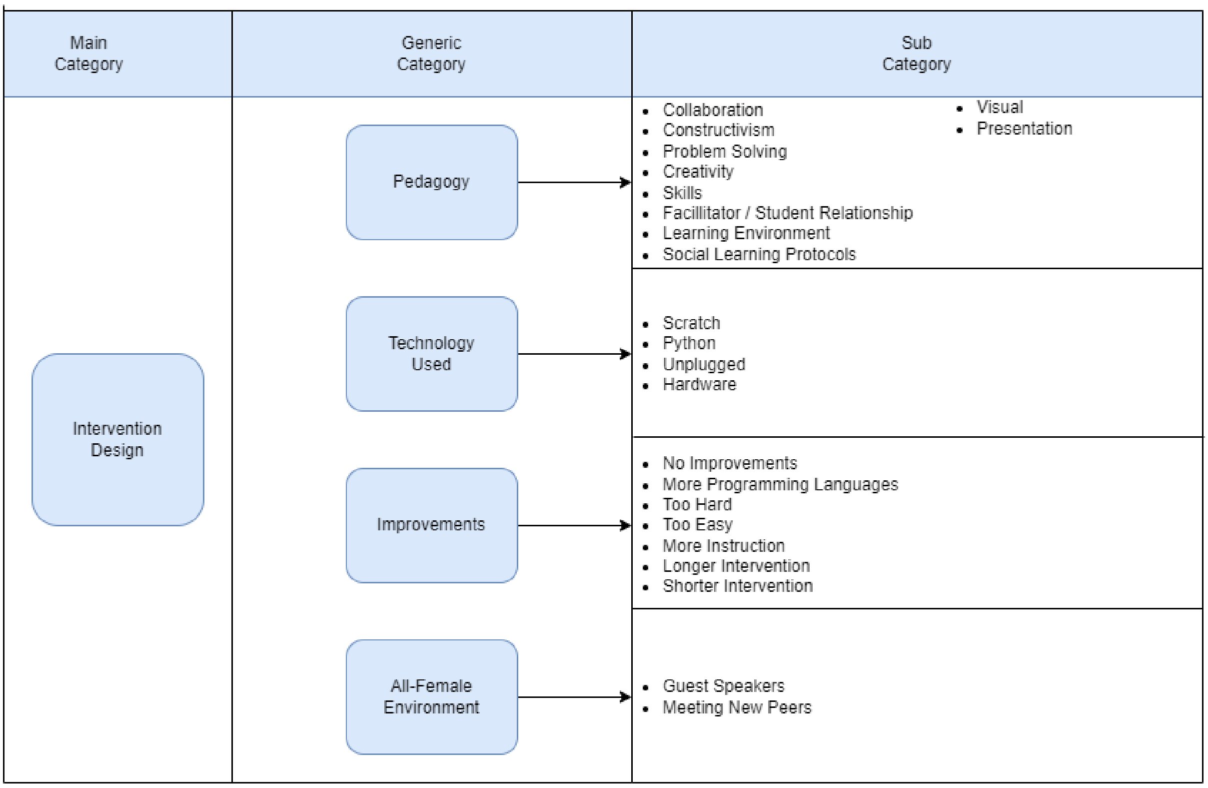


Figure 23: Intervention Design Categorisation Matrix

After a categorization matrix has been developed, all data are reviewed for content and coded for correspondence with or exemplification of the identified categories (Polit & Beck, 2004). In this study, this process was facilitated and expedited by the qualitative analysis software Nvivo. Coding Schema were developed (De Wever, Schellens, Valcke, & Van Keer, 2006; Gibbs, 2018) as frameworks that provided keywords, exemplary segments taken directly from the data, and notes on how the sub-categories were operationalised. Coding schema can provide a measure of reliability to a study, as they operationalise the coding process for peer-coding and analysis (Yin, 2014) or act as a tool for an “external auditor”(Creswell, 2003, p. 196). The schema used in this qualitative analysis are presented in Table 23 and Table 24 below.

Category	Sub Categories	Keywords	Examples	Operationalisation
Pedagogy	Collaboration Skills Creativity Problem Solving Presentation Learning Space Constructivist Visual Facilitator/Student Relationship Social Learning Protocols	Teams Groups Leading Skills-based Project Creative Presenting Learn by doing Brainstorm Environment	***It is a safe environment to learn in and does not feel like school. You are given a task and then told to solve the problem.*** ***I learned that I like working in groups and coming up with ideas in a group and creating things as a group*** ***It was a very interesting experience, I learned many things I would've probably struggled to in a normal classroom environment- if there even was a proper class for this at all.*** ***I learned better by using the computer through trial and error.***	Segments that refer to elements of Bridge21 pedagogy/project based learning in intervention design.
Technology Used	Scratch Python Unplugged Hardware	Scratch Python Puzzles micro:bit/Arduino etc	***Scratch is really not my thing and although I try to be patient with it I just can't and I find it really boring and stressful.*** ***I did really enjoy it I just wish we done more python and less scratch*** ***I learned that I enjoy thinking problems as the ones we did on Thursday with the cards and the bomb***	Segments that refer to the technology used in the activities.
All-Female Environment	Guest Speakers Meeting New Peers	Girls Women Female New people	**That listening to people's stories can be really interesting, and that it can influence me, especially as a girl.** **I enjoyed meeting the girls from different schools and talking to them about their knowledge of coding. I also found the people running it were really lovely and helpful.**	Segments that reference working in the female environment, meeting new people, female guest speakers etc.
Improvements	More Programming languages Too easy Too hard Make week longer Make wee shorter More instruction No improvements	Longer Harder Easier Demonstration	***I think we should start coding on the first day. I also think we should have learned a bit more coding languages like java*** ***Have a tutorial before each app with an instructions sheet to make it quicker and easier for the groups.***	Segments that suggest improvements to the intervention

Table 23: Intervention Design Coding Schema

Category	Sub Categories	Keywords	Examples	Operationalisation
Self-Efficacy	Computer SE Programming Ability Other SE	Confidence Ability Good Better Improved	***I can achieve great things when I step out of my comfort zone*** ***I learned that I could actually get a hang of using computers very quickly which I was surprised at*** ***I'm very bad at coding***	Segments referencing ability and confidence (Or lack thereof) with computers, programming or other aspects of the intervention
Future Intentions	Strong Pos_Intention Strong Neg_Intentions Motivation to learn more Unsure Just not for me	Future Career College Interest	***This was my first time learning about computers and I actually really enjoyed it. Before coming here, I had never considered doing anything in this field but I really like it now*** ***It was fun but I'm just not interested in coding***	Segments that indicate future interest, intentions and actions involving CS
Positive Perceptions of CS	Lack of previous experience Useful skills Better Understanding Interesting Gender Fun Enjoyable Stereotypes	Understanding Before Fun Enjoy Interesting Develop	***Before doing the course I hadn't a clue what computer programming was. I have a much better understanding of it now*** ***I am more interested in computer coding than I thought.***	Segments that indicate a positive perception of CS following participation
Negative Perceptions of CS	Difficult Unrealistic Boring Frustrating Not Interested	Hard Difficult Stressful Boring Frustrating Not Interested Not like real CS	***Because I am not that interested in it and I don't think it gives you a fair idea of CS in real life*** ***I have already done the course and I don't think I would benefit from doing another one because it really stressed me out and makes me sad.*** ***I usually am one to get bored easily and programming is quite repetitive and frustratingly difficult at times***	Segments that indicate a negative perception of CS following participation
Maths	Maths	Math Maths Skills	***I learned that CS isnt in fact all about coding and maths, and is much more creative.*** ***You don't have to be an expert in maths to do coding (learned that while one of the mentors was talking)***	Segments that reference maths in relation to CS

Table 24: Effects Coding Schema

6.4 Qualitative Data Analysis

The results of the quantitative analysis presented were strongly indicative of positive short-term changes across key attitudinal and intentional variables in particular concerning computer and programming self-efficacy, perceptions of CS pathways, statements of future intent, and personal belief statements.

In order to triangulate these findings and to explore potential relationships between the design elements of the intervention and its effects, a directed content analysis (DCA) of the qualitative data was carried out. The following sections will examine both aspects of the qualitative data findings in turn.

6.4.1 Triangulation of Quant and Qual Data

6.4.1.1 Computer and Programming Self-Efficacy

The self-efficacy generic category had three sub-category codes; computer self-efficacy, programming ability and other self-efficacy. Table 25 below presents the codes and number of occurrences of the code found in the qualitative data (n=418), surveys.

Category	Code	Sentiment	Occurrences
Self-Efficacy	Computer SE	Pos	79
		Neg	12
	Programming Ability	Pos	149
		Neg	15
	Other SE	Pos	107
		Neg	14

Table 25: Self Efficacy Code Occurrences.

The following direct quotes provide a representative sample of the types of comments (n=79) pertaining to computer self-efficacy (positive sentiment):

"I am more competent with computers than I thought."

"I am more capable with computers than I thought."

"I learned that I could actually get a hang of using computers very quickly which I was surprised at."

There were a small number of negative sentiment comments too, (n=12):

"I'm not really good with the computers"

"Mate, I'm a solid -2/10 with computers on a good day"

Although a number of the negative comments did mention how the programme might help them address their confidence:

"I'm bad with computers so I think this course helped me".

"Because I'm bad with computers, I would like to learn something new and I would love to create a game." (participant had indicated in the previous question that they wished to be considered for further workshops).

There were a total of 164 references to programming confidence and ability. This code was made distinct from the previous "computer SE" code in that it was applied when specific reference was made to computer programming. A sample of the positive sentiment comments (n=149) were as follows:

"I learnt that programming is not as scary and intimidating as it looks and is something I am now comfortable with."

"That I can actually code!- I didn't have a lot of confidence in my ability before this week"

"That I'm actually good(ish) at coding."

Similarly to computer self-efficacy, there were a number of negative sentiment comments regarding programming ability (n=15), again several comments qualified these statements with wishing to improve with further workshops:

"I am not good at coding."

"This was a fun experience however I don't think computer coding is one of my strong areas."

"I don't have talent in coding or computer programming."

"*I'm definitely not a genius in computer programming but I still do like the idea of studying computer science and this will help me learn more".*

"I'm still not the best with coding in general and I'd like to learn more"

While computer and programming self-efficacy were early pre-defined codes, an emergent code was that of "other" self-efficacy (n=121). This code was operationalised as any reference to confidence, efficacy or ability that did not specifically mention computers or programming. The author notes that it is possible that participants may have assumed the survey audience would gather that computer and/or programming ability was being referenced in such comments without specifically doing so e.g.:

"I learned that I should be more confident in myself and my abilities as I really enjoyed the workshop and learned a lot of valuable things."

"I learned that I underestimate myself too much. I am a lot more confident than I thought."

Nonetheless there were more specific references to confidence in meeting new people, speaking in front of groups, and working in teams:

"I learned that I can communicate very well with a group of strangers and I have confidence that was beneath my shyness."

"I think we learn way more by not worrying about asking people and being confident. That's how (personally) you get the best opportunities"

Again, there were a small number of negative sentiment comments (n=14), most of which indicated a wish to improve or learn more:

"I don't think I would come back as I don't think I will be good at it."

"Learned that I'm not good at this but I'm interested"

"*Because I think that I learned something in the week. I don't think I would still rate myself excellent at it though, but I still feel good."*

"Because really interesting in that, but I find it need more bractice [Sic] *and more trys to be better on it."*

The author contends that these qualitative findings strongly support those of the quantitative that related to computer and programming self-efficacy (MSCE, Programming Ability Ratings) Section 6.3.1, and furthermore are indicative that confidence and self-efficacy in their broader sense was being developed throughout the intervention. Further analysis of this theme and how it relates to other findings in the qualitative data will be explored later in the chapter.

6.4.1.2 Future Intentions with CS pathways

The future-intentions generic category had five sub-category codes: motivation to learn more, strong positive, strong negative, unsure and "just not for me". Table 26 below presents the codes and number of occurrences of the code found in the qualitative data (n=418), surveys:

Category	**Code**	**Occurrences**
Future Intentions	Motivation to learn more	212
	Strong Positive	80
	Unsure	13
	Just not for me	78
	Strong Negative	24

Table 26: Future Intentions Code Occurrences

The author considers that the sub-category codes above are in fact "dimensions" of the generic "Future Intentions" code (Gibbs, 2018), each indicating future interest, intentions and actions (or lack thereof) involving CS. This coding also makes further analytic questions possible as the characteristics of each code are contained by separate attributes (Gibbs, 2018). In this case the author can examine relationships between dimensions of future intent and other themes within the two coding schema.

The most populated of these codes is "motivation to learn more" (n=212), which was categorised by data that indicated a desire to learn more about CS or programming but is distinct from "strong positive" in that career or college pathways were not mentioned. Below is a representative sample of direct quotes coded:

"I would really love to take part in other coding workshops as I think that as a skill coding is very useful and I would love to improve my coding skills further"

"I like working here and I think computers are really important right now, I could use more classes to learn more."

"I found this week interesting and I want more knowledge of coding, computer science etc."

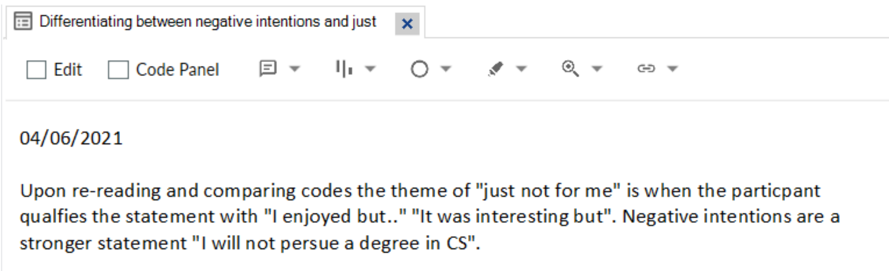
As mentioned above, the "strong positive" code required a response to mention either college or career pathways in a statement of positive intent, n=80 references were coded:

"I learned that I would love to work in a big company like Google one day."

'I've realised how much I love computer science and coding. I will do more to educate myself on computer science. I've decided that I definitely want a career in computers and to do a college course in computer science"

"This was my first time learning about computers and I actually really enjoyed it. Before coming here, I had never considered doing anything in this field but I really like it now".

Closely following the "strong positive" code in terms of references, "just not for me" (n=78) was an emergent code found inductively in the early stages of the data analysis. It is differentiated from the "strong negative" and "unsure codes" in that it qualifies the negative intention with a generally positive or personal one. A memo by the author illustrates this differentiation:


Differentiating between negative intentions and just

Edit Code Panel

04/06/2021

Upon re-reading and comparing codes the theme of "just not for me" is when the particpant qualfies the statement with "I enjoyed but.." "It was interesting but". Negative intentions are a stronger statement "I will not persue a degree in CS".

Figure 24: Memo on "just not for me" code

A sample of quotes further demonstrates this categorisation of data:

"Personally coding isnt for me, there was nothing wrong with how it was carried out I just didn't enjoy it."

"I really enjoyed the programme but I don't think computer science is for me."

"I think the programme was good but it made me realise that I don't think coding is for me."

The next most populated code was "strong negative" (n=24), categorised by a stronger statement as referenced in the above memo:

"I will not have a career in computer science."

"I wouldn't like to do computer science in college"

"I am definitely not doing computer science in college"

The final code in this category was "unsure" (n=13), which was defined by statements indicating uncertainty regarding intent:

"It was a good experience but I'm not sure if I will continue."

"I enjoyed it but wouldn't do it again because I don't think it's what I want to do but that could change."

"I feel that coding may not be for me and that I'd pursue something else in future but I'm still unsure at the moment."

These findings give support to the intentional variables results reported in the quantitative data where a statistically significant positive differences were found in pre to post-intervention mean scores. The five dimensions of the "future intentions" category also give a deeper and richer understanding of intent by categorisation. On the positive aspect, students either gave reasonably strong statements regarding CS pathways, or at least a motivation and willingness to learn more without committing themselves further. On the less positive side, students could affirm their lack of interest following the intervention in strong terms or somewhat softened by an enjoyable experience. The author would argue both of the aforementioned are still positive outcomes from the intervention. If participants' having invested 4 days in an introduction to computer science left armed with a more informed decision regarding CS pathways then the intervention had achieved its primary objective.

At this point it should be acknowledged that this data was mined from surveys in which the participants knew the audience (facilitators) with whom they developed a rapport during the week, therefore overly positive reporting is a threat to validity that must be considered. Notwithstanding, the author considers that the quotations were coded in units of entire responses to capture the nuances and voice of participants in context. To that end it is argued that this gives an authentic sense to the analysis of the data presented and may even suggest that the participants were truthful and genuine in their responses. This approach is consistent with aspects of natural science model of rigour in qualitative research as discussed by Ezzy (2002, p. 52).

It is also prudent at this point to remember that statements of intent in the short-term may have little bearing on longitudinal outcomes, a key limitation of outreach programmes that measure intentional variables only in the short-term.

6.4.1.3 Perceptions of Computer Science

The perceptions of CS generic category was split into 3 filter categories; positive, negative (sentiments) and maths. This generic category contained the largest number of codes (n=14) in the Effects Coding Schema as presented in Table 27 and Table 28

Category	**Filter-category**	**Codes**	**Occurrences**
Perceptions of CS	Positive	Enjoyable	306
		Interesting	145
		Better Understanding	132
		Fun	118
		Useful Skills	52
		Lack of prior experience	32
		Gender	7
		Stereotypes	3

Table 27: Perceptions of CS (Positive) Code Occurrences

Category	Filter-category	Codes	Occurrences
Perceptions of CS	Negative	Not Interested	54
		Difficult	52
		Frustrating	34
		Boring	31
		Unrealistic	13
	Maths	Maths	14

Table 28: Perceptions of CS (Negative) Code Occurrences

Given the volume of codes within the category, the positive filter-category codes have been loosely re-grouped by association for ease of reporting:

a. (enjoyable, fun, interesting)
b. (better understanding, lack of prior experience, useful skills)
c. (stereotypes, gender)

The group a codes were the most descriptive within the filter-category and tended to be coded based on the participants own direct use of the words with a representative sample below;

"*I would like to learn to code more as I found it enjoyable.*"

"I enjoyed learning the new information and creating stuff."

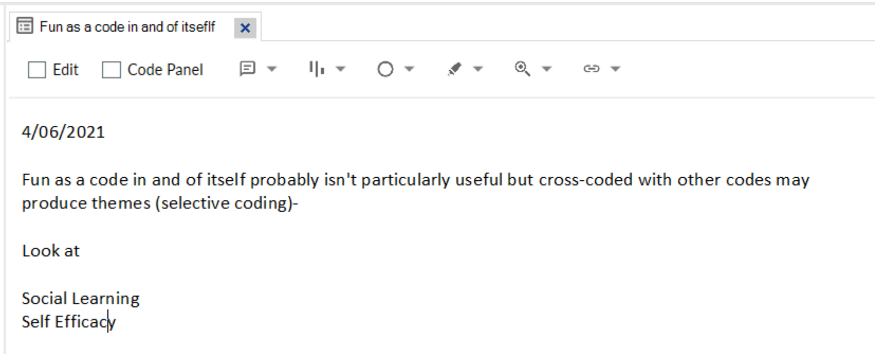
"I found this workshop fun therefore I would definitely come for the next workshop."

"Coding is kinda fun."

"I liked the whole vibes around the workshop, and I learnt a lot of new things it really sparked an interest in me."

"I found this week interesting and I want more knowledge of coding, computer science etc…"

The frequency of these codes were considerable, suggesting that many participants came away with positive perceptions of CS from the intervention. Nonetheless the author considers that these codes capture data on a shallow, or low analytical level. A memo written on the "fun" code during data analysis summarises the author's thoughts on this and creates a reminder to cross-reference the code at a later stage:


Fun as a code in and of itseflf
Edit Code Panel

4/06/2021

Fun as a code in and of itself probably isn't particularly useful but cross-coded with other codes may produce themes (selective coding)-

Look at

Social Learning
Self Efficacy

Figure 25: Memo "Fun as a code in and of itself"

The second group of b codes were arguably more analytical in nature than the descriptive group a codes. In these codes participants acknowledged how the intervention had given them an opportunity they had not previously had to explore CS, that they now had a better understanding of CS, or that the skills they had acquired during the intervention were valuable. A sample of the coded data is presented below:

"I have a better understanding of the world of computers and how useful they are in everyday life"

"Because I feel like I have a better understanding of what computer science + programming is about."

"This programme opened my eyes to all the opportunities in C.S an I.T, I learned a lot and would like to increase my knowledge even more."

"I got a better understanding of what it really is"

"The course it's helped me realise I don't think a career in computer science would suit me."

"Coding has never been an interest of mine because I had never actually done it. By spending the 4 days here in Bridge21 I have learned so many new skills that will be very helpful in the future."

"I already wanted to learn about coding but I never had the opportunity and I think that this course helped me to learn about coding and it also helped me to find out what I want to study in college."

"It's an important skill to have and theres loads of jobs to do with coding/computers."

"Although I don't want to pursue a career in it, it is a very valuable skill to have and I feel it will stand to me in the future."

"Coding and learning more about computer science is very beneficial as it is something very relevant and applicable to most careers so finding out more about coding would be interesting."

The c group codes, while sparsely referenced in the data, did provide some insights on the gender-based and stereotypical views of CS:

"I always thought both men and women could take part in programming but now I believe it more and want the percentage of women who have careers in coding to rise"

"Computer programming is for both boys and girls."

"It was fun and different compared to other workshops we were doing and it's nice to see girls take part in a 'mens' profession."

"I learned that I would like to do computer science in college which I never expected to say because of all the stereotypes you hear about computer science."

"not everyone who does stuff with computers are a nerd"

One participant went so far as to proclaim her "geek" credentials with pride:

"I'm a "geek". I'm always finding tutorials online when it comes to computer programmes I've never used before."

Another unique (and amusing) comment suggested that the intervention should give boys an opportunity to participate in the interest of equality!

"I overall loved the programme and would like to learn more coding or participate in more programmes. However, I wish this was for both boys and girls to give everyone the same opportunity of getting to know coding."

There were 5 negative filter-category codes. The most populated of the codes "not interested" (n=54), with some responses comparable to the "just not for me" code in intentions, while others were more definitively negative:

"I am not very interested in programming/coding."

"I hate computers, coding and problem solving and have no time for algorithms."

"I did enjoy this course but I know for a fact that I would never consider a career in computer coding and I don't really have any interest in it."

"I enjoyed the week but I'm not extremely interested in it"

The second most populated code was "difficult" (n=52):

"I found it very difficult at times."

"I don't think I would come back as I found it all a bit hard and not for me but it was a good course just not the coding was hard."

"I found this week a bit challenging."

Some participants qualified statements of difficulty with positive sentiments:

"It's interesting but it's also really hard to understand that for me."

"It was fun and I really enjoyed it but found the programming difficult sometimes."

"Although I really enjoyed it and got better there were a lot of parts I found difficult and think I won't be able to understand."

Closely related to difficult, the next most populated code was "frustrating" (n=34):

"Sometimes I find working with computers frustrating"

"Because on Friday finishing our game was really frustrating because it kept glitching"

"I can become very frustrated and be very impatient if I can't complete a task."

"Personally, I find making games extremely frustrating an unrewarding because you can work all day at something for it to be a pixelated mess."

Akin to "difficult", some participants did combine statements indicating frustration with some positive sentiment:

"I learned that coding can be stressful but the results are satisfying."

"I had a good time I enjoyed it but at the same time the scratch programme frustrated me because it was so literate."

The next negative filter-category code was "boring" (n=31):

"I found the course too tedious."

"I get bored easily and don't like sitting in front of a screen all the time."

"I thought the programme was very well run and organised. However as I have very little interest in computers etc I found the computer work quite boring."

"I did not like the amount of time we spent on the computers doing tiny details as I get restless and bored."

The final negative code in the category was "unrealistic" (n=13). This was an emergent code characterised by participants commenting on how the course was unlike "real-life" or "actual" college CS or jobs:

“Because I am not that interested in it and I don't think it gives you a fair idea of CS in real life.”

“Talk more about proper jobs + coding that you would use in real life.”

“We didn't do anything more difficult than scratch, I didn't feel that it reflected college level computer science.”

An additional perceptions code was “maths” (n=14), with largely positive sentiments, several comments disassociating CS from maths:

“I preferred the mathematical side.”

“I really enjoyed the coding and maths stuff and can see myself doing it again in a more serious or "difficult" way”.

“I learned that CS isnt in fact all about coding and maths, and is much more creative.”

“You don't have to be an expert in maths to do coding (learned that while one of the mentors was talking)”

Given the literature linking perceptions of CS as a heavily mathematical area with girls’ lack of interest, one may have anticipated more references made to maths and CS/programming. The intervention activities certainly required engagement from the participants’ in a number of distinct mathematical curricular areas, some well above their current school level (variables, Boolean logic, operators, conditions, trigonometry, random numbers). These concepts were consistently used in games and other programs throughout the workshops, although typically in the spirit of constructivist as opposed to didactic pedagogy as this participant may be acknowledging:

“I learnt a bit more maths threw [Sic] the games rather then real maths.”

Baseline findings from the quantitative data Section 6.3.1 that suggested a reasonable level of mathematical competency in the demographic as reported in their levels and grades may also have mitigated the participants’ responses in the qualitative survey instrument.

6.4.1.4 Triangulation of Quant + Qual Findings Summary

The results of the pre-experimental survey analysis provided strong quantitative indicators of positive change in the short-term across key attitudinal and intentional variables, chiefly in areas of computer and programming self-efficacy, future pathways in CS and perceptions of the field. The directed content analysis of the qualitative data presented above goes someway to confirm and to validate these findings through several mixed-methods design approaches (Creswell, 2003):

- Data Transformation: The qualitative data was quantified. Codes were developed within the two schema and their occurrences were counted, enabling the author to compare results between the data sets.
- Use of a concurrent nested strategy: The embedded qualitative data enabled the author to describe aspects of the participants’ experience that could not be easily quantified. In that sense, the advantages of the two approaches enabled the author to gain perspectives through the different data types.

The author argues that with this rationale and the relevant findings RQ1: What is the short-term effect of the intervention’s approach? is addressed.

A principal limitation of the pre-experimental design was that it did not yield data concerning if and how design aspects of the intervention affected these positive changes which relates to RQ2: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term change?

The following section will now return to the qualitative data to explore these themes.

6.4.2 Intervention Design and Effects

6.4.2.1 Pedagogical Approach

A clear statement of pedagogical design is what makes the intervention described in this study unique to similar empirical studies and general outreach programmes as discussed in Chapter Meta-Analysis of the Outreach Space. The CodePlus intervention is a functioning example of the Bridge21 pedagogy, encompassing all elements of its learning model. Figure 26 below (J. Lawlor et al., 2016) illustrates the eight elements of the model:

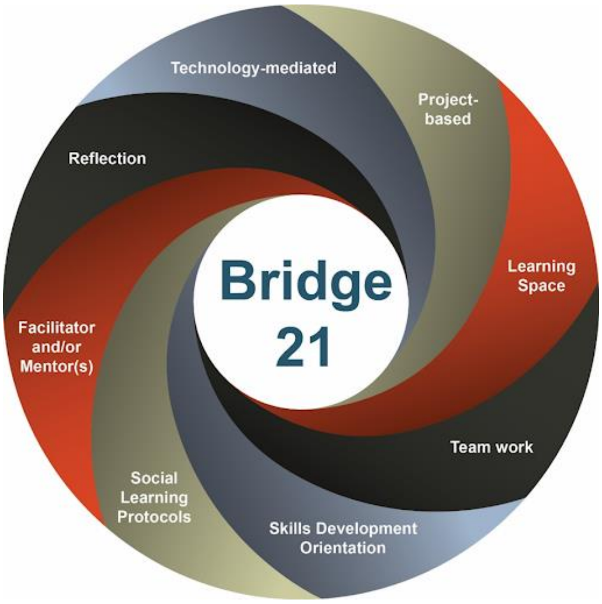


Figure 26: Bridge21 learning model (J. Lawlor et al., 2016)

All elements of the model are reflected in the intervention design coding matrix (Figure 23) and coding schema (Table 24), with directed content analysis used to examine these themes in the data. Based on the theoretical and empirical data reviewed in the literature, it was hypothesised that the pedagogical design elements of the intervention would contribute to positive effects in key attitudinal and intentional variables. The following sections will review these elements in the context of the qualitative data analysis.

1. Collaborative Learning

This code was categorised by any segments referencing the collaborative nature of the learning during the intervention. In the early stages of coding the data, “leadership” and “teams” were separate codes but were both later merged into collaborative learning as the final occurrence count of leadership (n=13) was relatively small by comparison to “teams” (n=307). Table 29 below presents the number of occurrences in the data to collaborative learning by sentiment:

Code	**Sentiment**	**Occurrences**
Collaborative Learning	Positive	281
	Negative	41

Table 29: Collaborative learning code occurrences

While the findings are heavily concentrated towards positive sentiment, the author notes that there was considerable variance in the depth of responses. Below are several representative examples of what the author considers to a low-level positive comment on collaborative learning:

“I like groupwork.”

“I liked working with small teams.”

“I like working in groups.”

“I like being the leader of a team.”

Other comments gave greater complexity, showing some metacognition:

“I enjoyed working as a team because you learn from each other.”

“*I find it easier to understand something when I work with others.”*

“It is better to work in a group because it can help when you have problems.”

“I learned that I'm pretty good at being in teams and got on well with one another. I would learn things by asking for help by my teammates.”

“I learned that I am more open to doing new things than I thought. I am more of a leader than I thought. I can talk to others better than I thought.”

Other comments went further to link collaborative learning and learning programming or other CS activities in the workshop:

“I learned that how I learn is to figure out in groups when doing computers.”

“Working as part of a team is not that scary and it is very helpful in problem-solving situations, it was a chance to collaborate and share.”

“I learn to do game with help of other person and work tother [Sic] *for do the game better”*

"I get a first idea from others but then developed myself- with the 5l/3l trick."

Examining links between the collaborative learning element of the intervention's design and effects (self-efficacy, perceptions and intent) through pattern matching and explanation building strategies (Yin, 2014) will be examined later in Section 6.4.2.2. Given the heavily team structured nature of the intervention, the frequency of references to collaborative learning in the qualitative data was not surprising. The data as reported above was for the most part positive, however there were a proportion of data found in the collaborative learning code with negative sentiment (n=41), which are worthy of investigation. Akin to the positive sentiment, the negative codes could be further split by three themes: "prefer working alone to teamwork, I didn't like my team or would prefer to choose our own teams and would prefer team smaller groups":

"I would like to learn more and understand how to do everything on my own and not in a team."

"I work better alone."

"*I prefer working alone but I don't mind working in a group."*

"Maybe team of 3 not 4, four is to [Sic] *much"*

"Perhaps before tasks are set for the students on computers give a more detailed instruction or demonstration. Also I believe if people were put into groups of 2 or 3 they would get a more hands on experience than in a larger group."

"I work well in 2s and get more done than when working in a big group"

"I had a great few days in bridge21 and all the leaders were very nice. - It would be better in my opinion if we were taught in small groups to use scratch as I had never used it before and didn't have a clue how to use it."

"I learnt how to work in a team but found it challenging when some people on the team don't do their part or help out."

"You should let us choose our groups because in most group one or two people become the dominant people

"Possibly switch groups around every day so people get to communicate and work with other personalities that they're more comfortable or work better with. and didn't let the two others do much."

A justification on the protocols for team size and selection is provided in Section 4.3.1, although it is interesting to explore alternative perspectives from the participants regarding these design elements. The author also considers similarities between the theme of "I prefer working alone" and the code "just not for me" pertaining to future CS pathways in that universally positive reporting on personal preferences regarding teamwork would be a suspicious result. In this sense the author argues that these data give greater validity to the positive sentiment findings.

2. Constructivist learning and problem solving

The next most populated code within the Intervention Design Matrix was "constructivist" (n=118) which was operationalised as any reference to the constructivist learning style (Piaget, 1964), inherent to the intervention design. This is to say any segment acknowledging a "construction" of learning during the intervention. While this process was nuanced (unsurprisingly no participant used the word constructivist), and undoubtedly influenced by the author's epistemological positioning, some examples of participants defining this type of learning in their own language are includes with terms such as:

"hands-on"

"playing"

"mind maps/brainstorming"

A code closely related and arguably an aspect of constructivist learning was problem solving which yielded 65 references in the qualitative data. This code was distinct from constructivism in that segments made direct reference to" problem solving", "puzzles" or "trial and error".

Unsurprisingly there was some overlap between the two codes (n=12) which were cross referenced using the Nvivo matrix query function (see Table 30 below):

Code	**Sentiment**	**Occurrences**
Constructivist	Pos	109
	Neg	5
Problem Solving (PB)	Pos	65
Constructivist/PB cross reference	Pos	12

Table 30: Constructivist and Problem Solving Code occurrences

Below is a representative sample of the constructivist coding references:

"I am a very hands-on learner. Being able to mess around and play with code really helped my understanding."

"I understand things more when I'm doing them."

"I've also learned that when I am given the freedom to play around with something and figure it out myself I learn better."

"We were guided rather than told what to do. We learned python. It's slightly more laid back and I don't feel as shy to ask if I have trouble with a code."

"It's a guided learning experience, rather than memorising. Way more interactive/engaging."

"I found that by showing me and allowing me to put what I learned into action allowed me to retain what I had learned and put it to use far better, I also remembered the information better."

There were a small number of negative sentiment references concerning constructivism, 3 related to too much time spent brainstorming:

“Spend less time brainstorming because it loses my attention and I don't listen.”

The other two referenced were more metacognitive in their nature, reflecting on personal preference regarding constructivist learning:

“I learned that jumping into a task as intimidating as it is, it allows you to figure things out by yourself and you end up learning more. I know I initially complained about this.”

“I think the programme is very good and able for newcomers but there's not much "traditional learning". We are expected to just dive right into the task without a prior brief. I don't completely hate this though because it's more of an intuitive process and we learn ourselves but I'd like just a little walk through.”

All references to problem solving (n=65) held positive sentiment and many segments gave some evidence of metacognition:

“I am a good problem solver.”

“I learn from mistakes.”

“I really enjoyed my experience, I ended up loving problem solving and got excited about showing my program.”

“My problem solving skills are improving. By taking part in the different exercises and applying the solutions to scratch I became more confident.”

“I find it easier/satisfactory (?) if I learn things through trial and error.”

“Trial and Error help me to understand what will and won't work.”

The above data can be considered as a strong indicator in support of the constructivist underpinning of the intervention’s design. In their own words, participants expressed strong awareness of the nature and value of this learning taking place during the intervention. The author does consider nonetheless that in most CS outreach interventions learning would be of a constructivist or problem solving nature given that activities are typically centred around programming and hardware. In Section 3.6.2 the author pointed to a lack of empirical and theoretical data concerning pedagogical design in all-female CS outreach. This is not to assume that outreach programmes do not engage in constructivist practices but rather to consider how this design aspect of programmes is potentially under-explored. This question will be revisited later in the thesis for further discussion.

3. Social learning protocols, facilitator and student relationships and the learning environment.

Three related and relatively frequent codes were that of social learning protocols (SLP), facilitator and student relationships (FSR), and the learning environment (LE). All three codes are key elements of the Bridge21 model (J. Lawlor et al., 2016) and were anticipated in analysis of the qualitative data. Table 31 below presents the occurrences and cross referencing of codes within this subset:

Code	Sentiment	Occurrences
Social Learning Protocols (SLP)	Pos	96
Facilitator and Student Relationships (FSR)	Pos	44
Learning Environment (LE)	Pos	44
	Neg	1
SLP/FSR Cross references	Pos	17
SLP/LE Cross references	Pos	16
FSR/LE Cross references	Pos	2

Table 31: SLP, FSR and LE code occurrences

The coding of "social learning protocols" is nuanced and essentially captures a "structured informality" where friendly open and relaxed atmosphere permeates the environment and the protocols at play are based on trust and responsibility between the learners and facilitators (J. Lawlor et al., 2018). Several deliberate measures are taken to relax formality, such as having the facilitators and participants on a first name basis (as opposed to the formal "Miss" and "Sir" protocol with the school environment), no uniforms and a typically less authoritarian environment in which participants were free to move around and discuss ideas. While this aspect of the Bridge21 learning model is well-defined, the definition was expanded in the coding from emergent data to include references to a safe, helpful, supportive or relaxed learning atmosphere. The segments did not need to give specific reference to the programme facilitators either as in the FSR code, and in some cases were referencing other participants or the learning community as a whole. All segments (n=95) were positive in their sentiment with a selective sample presented below:

"I thought the programme was very educational but without the same environment as school. It was more relaxed however I learned very easily. I also enjoyed working with my group as I made friends with people outside my school."

"I learned a lot and it was such a nice atmosphere during the whole course."

"It is a safe environment to learn in and does not feel like school. You are given a task and then told to solve the problem."

"I learned that I'm pretty good at being in teams and got on well with one another. I would learn things by asking for help by my teammates."

"Laid back but still structured learning. Help/Advice on how to improve available."

"I think I enjoyed the course so much because we had a lot of independence and we were trusted to do our own thing and if we needed help there would always be someone."

"I learned that I'm confident in coding or computer programming. If I was confused I would ask others for help."

"I work a lot better in an independent, relaxed learning environment."

"I learned that I often learn from mistakes that I make and it's not embarassing [Sic] *to ask for help."*

Closely related to the SLP code was that of FSR (n=44). As aforementioned the operation of this code differed somewhat to SLP as it required direct reference to the facilitators or mentors, sometimes in the lexicon of the students "helpers", "teachers", "leaders" with some considerable cross-referencing between the two (n=17). All codes were of positive sentiment and a representative sample of comments are provided below:

"No, I really liked everyting [Sic] *& the mentors were amazing."*

"All of the staff were really helpful and motivating and made the experience enjoyable, thank you."

"Because we got treated really well and they explained and helped us with the computers."

"It was a chilled out experience- I didn't feel extreme pressure but I learned loads the leaders were encouraging and I got to create some great things in my own time."

"The team (staff) were very helpful and interactive, they also gave us fun activities to help us learn more about coding and technology."

"the people who run it have a more open minded/chill approach and method of teaching, I feel that made the course for everyone more enjoyable and more inclined to participate as we weren't being forced into doing the work."

The final code in this sub-set was "learning environment". This anticipated code (previously named "learning space"), was based on the considered role of the learning environment in the Bridge21 learning model and subsequently embedded in the intervention. Dimensions of this code emerged through analysis of the qualitative data as an Nvivo memo below captures:

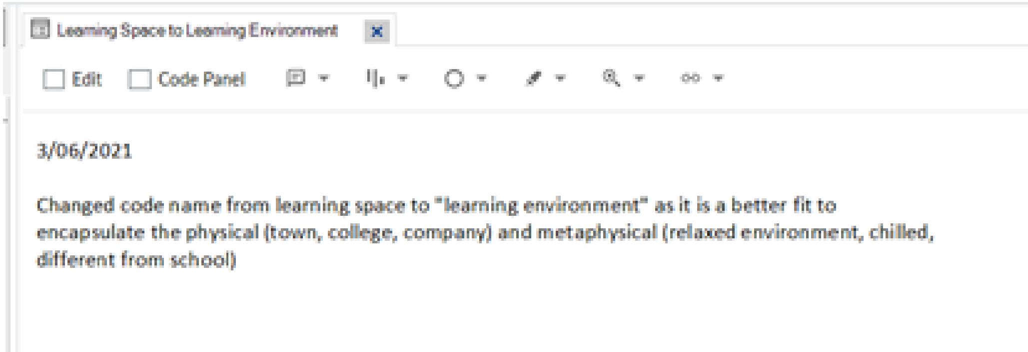


Figure 27: Memo "Learning Space to Learning Environment"

Within this code, participants are describing aspects of the physical or metaphysical learning environment of the intervention. While there is some cross-referencing (n=16) with SLP, the author argues that this code is defined in the words of the participants as a learning environment "not like school", contra to a "normal classroom", "outside school" in addition to references concerning the college or city-centre location of the college and intervention. A sample of quotes illustrating acknowledgement of a "not like school" environment are as follows:

"Great alternative to school."

"I thought the programme was very educational but without the same environment as school. It was more relaxed however I learned very easily. I also enjoyed working with my group as I made friends with people outside my school."

"It is a safe environment to learn in and does not feel like school. You are given a task and then told to solve the problem."

"It was a very interesting experience, I learned many things I would've probably struggled to in a normal classroom environment- if there even was a proper class for this at all"

The comments regarding physical space generally concerned the college or city-centre environment. In the later years of the intervention, several workshop groups visited the nearby Google offices as part of the 4 day programme for a tour and to meet some female professionals which was mentioned in this code:

"TCD was nice and I would consider going."

"I really enjoyed this programee [Sic] *and had lots of fun using my creativity and talking to new people and also seeing different parts of trinity college."*

"Enjoyed coming into town everyday."

"It was a good interesting experience and made me feel real mature having to make my own way in and out."

"It was a good experience going to google and definitely [Sic] *enjoyed it."*

with the only negative sentiment comment in the subset concerning the long bus trip!:

"That it's a really long tiring journey to get into Trinity."

Arguably, the above findings are a strong endorsement of the corresponding design elements of the learning model. Nonetheless, the author qualifies these findings by considering that most outreach programmes in the non-formal learning environment could yield similar findings by their virtue of being run outside of a school environment, including the role of enthusiastic volunteers and mentors who would have a less authoritatively defined role than that of a teacher. The author also expected to find more references to the college, as setting CS outreach interventions on campus is a common strategy of such initiatives as seen in the empirical data (see Section 3.6.2).

4. Skills and Presentation

A related pairing of codes that emerged from analysis of the qualitative data were “skills” and “presentation”. Skills-based (as opposed to content-orientated) learning is at the core of the Bridge21 learning mode, in turn influenced by the 21st Century Skills Paradigm. Presentation is a core element of the Bridge21 activity model. Both codes emerged strongly from the data and are logged by sentiment in Table 32 below:

Code	**Sentiment**	**Occurrences**
Skills	Pos	36
	Neg	2
Presentation	Pos	34
	Neg	4
Skills/Presentation cross reference	Pos	1

Table 32: Skills and Presentation code occurrences

Sentiments were largely positive for both codes. The skills code was operationalised by segments that referenced skills development during the intervention. These coded segements could be further categorised by reference to communication skills, tech skills and unspecified “skills” as cited by participants. Communication skills were the most common of these:

“I improved my communication skills.”

“I learned that I'm a good listener.”

“I've improved on my communication skills”

“I learned that I can communicate very well with a group of strangers and I have confidence that was beneath my shyness.”

This was followed by references to more general skills development:

"It was fun and I got to learn new skills and meet new people."

"I learnt a lot of new skills and developed my knowledge in computer science."

"I learnt that I can pick up new skills quite quickly."

There were a small number of references to tech skills (usually specific):

"Learned how to make a game and movie."

"how to add music into games/export stuff."

There were also a small number of negative sentiment skill codes (n=) with students reflecting on their own communication skills:

"I don't listen very well"

"I noticed that I am a little poor at commication amoung [Sic] *team members."*

Consideration was given to merging the "communication" and "presentation" codes during analysis of the data. as was splitting the "skills" code into sub-codes. The memo below illustrates this consideration whilst analysing the data:

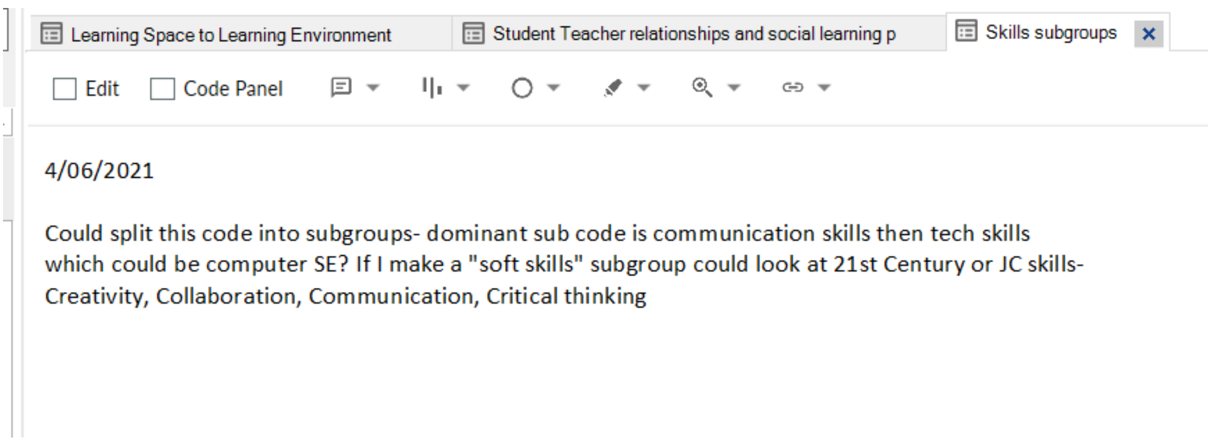


Figure 28: Memo "Skills Subgroups"

Ultimately, the skills group was not split and the presentation code was kept separate. This was because the other "soft skills" codes were already included by the "collaboration" and "creativity" codes within the Intervention Design Matrix. The decision to keep "presentation" separate was due to its distinctive role in the activity design model and the results of a matrix coding query that cross-referenced just one result between communication and presentation. The presentation codes were operationalised by references made in the data to the presentation element of the intervention design and for the large part carried positive sentiment (n=34):

"Oral presentation skils [Sic], I'm no longer afraid to talk in front of other people present in front of a group with confidence which I usually avoid."

"I've grown much more confident working in groups, when presenting I found I was talking no problem. Throughout the entire week I found talking becoming easier".

"I learned that the more I do presentations the more comfortable I get speaking in front of people."

There were a small number of negative sentiment comments coded to "presentation" too:

"I'm not good at presentations."

"I don't enjoy talking in front of others but I tolerate it cause I'm not bothered to complain"

The qualitative data findings relating to skills and presentation can be considered as a further endorsement of the intervention's pedagogical underpinnings and comparable to other findings from research involving the learning model. The following section will examine the final two codes in the pedagogical approach generic category with the Intervention Design Matrix.

5. Creativity and Visual

A final pairing of codes: "creativity" and "visual" completed the generic category of "Pedagogical Approach" in the Intervention Design coding matrix. The code occurrences by sentiment are presented in Table 33 below:

Code	**Sentiment**	**Occurrences**
Creativity	Pos	43
Visual	Pos	36
	Neg	2

Table 33: Creativity and Visual code occurrences.

The "creativity" code was anticipated, based on questions concerning perceptions of CS, taken from and used in other Bridge21 studies (Sullivan et al., 2015; Tangney et al., 2009). The "visual" code was developed inductively, emerging as a theme from the process of analysing of the data. The “creativity” code was operationalised as any segment that referenced creativity, designing or developing ideas. The segments coded can be further categorises into three themes: students stating that they are creative or more creative, students stating that they enjoy being creative, students recognising aspects of the intervention as being creative or allowing them a degree of creative freedom:

“I can be creative.”

“I learned that I'm good at making new ideas.”

“I like creating new things + develop my ideas.”

“I enjoyed the creative part of making a game more than the coding part.”

“It was really fun and we had a lot of creative freedom + everyone was lovely.”

“I learned that computer science requires more creativity than I thought before.”

The second code “visual”, was operationalised as any reference to visual learning including brainstorming and mind maps. The sentiment was largely positive with students either stating their enjoyment of learning visually or reflecting on their own learning preferences as visual learners (n=36):

“I'm a very visual learner.”

“I understand things better visually.”

“I learned that I learn coding best with visual things.”

“I enjoyed the brainstorming because it was a great way to wake everyone up.”

There were two negative sentiment comments coded to “visual”:

“I don't like visuals.”

“If I have an interest, just visual (my way of learning) is not enough.”

The above data gives a deeper understanding the intervention affecting perceptions of CS and the participants’ metacognitive understanding. It is clear that a proportion of students recognised either the activities or their own learning preferences as creative or visual. These findings prompt further directions for future research.

6.4.2.2 Pedagogical Approach Vs Effects Matrix

The qualitative analysis presented above uncovers a number of themes supporting the pedagogical underpinnings of the intervention design in terms of providing a learning experience that was conducive to offering students both a deeper understanding of what CS involves and increasing interest in CS pathways. Section 6.4.1 (Triangulation of Quant and Qual Data) compared the findings of the quantitative data with corresponding qualitative data to further validate the data. Section 6.4.2.1

(Pedagogical Approach), explored the qualitative findings pertaining to individual components of the intervention's pedagogical approach in an attempt to address Research Aim 2:

RA2: To gather and analyse data on the previously under-examined role of pedagogy in the design and delivery of a computer science outreach programme.

In order to further explore the role of pedagogical approach and to attempt to identify any causal relationships that may exist between the pedagogical approach and the intervention's design, a number of matrix coding queries were run between the two coding schema.

Table 34 below presents the results of the matrix coding query that provided results of the self-efficacy generic codes cross referenced with the pedagogical approach codes.

	Collaboration	Constructivist	Creativity	Facilitator and Student Relationship	Learning Environment	Presentation	Problem Solving	Skills	Social Learning protocols	Visual
Computer SE	1	0	0	0	0	1	1	1	0	0
Other SE	5	1	1	1	3	8	1	3	2	0
Programming Ability	4	1	0	1	1	2	4	1	1	0

Table 34: Self-efficacy VS Pedagogical Approach Matrix

There were 44 cross-referenced codes in total. The Computer SE row shows minimal cross-referencing between the codes (n=4). The Other SE row yielded the most cross referenced codes (n=25) with collaboration (n=5) and presentation (n=8) the most populated, a sample of the coded segments from this row are provided below:

"I truly enjoyed being put in uncomfortable situation as we were put in groups I also enjoyed learning how to code."

"I should credit myself more because I do the right thing but usually think I'm wrong so get rid of my idea. I know a lot and have a creative mind to learn about new things."

"I learned that I am more open to doing new things than I thought. I am more of a leader than I thought. I can talk to others better than I thought."

"I am and can be more confident when around people who are equally just, the girls made the experience more enjoyable because we were all friends. There was no room to feel anxious especially in the setting."

"I am able to present in front of a group with confidence which I usually avoid."

"I can talk in front of a big crowd without being shy or caring what others think."

The Programming Ability row yielded 15 cross-references, most notably in collaboration (n=4) and problem solving (n=4), a sample of segments from the row are provided below:

"I definetly [Sic] *felt that I have hugely improved my knowledge on programming and coding through working in teams and it was very engaging."*

"How capable I am at coding and being given no instruction is a good thing."

"My problem solving skills are improving. By taking part in the different exercises and applying the solutions to scratch I became more confident."

"I learned that I'm confident in coding or computer programming. If I was comfused I would ask others for help."

These findings, while modest in numbers by comparison to the data set (N=418), suggest some positive links between the pedagogical elements of intervention's design and the self-efficacy. It would be audacious to state that the results of the above findings constitute a strong causal path between the pedagogical design elements and self-efficacy effects, however these findings could be bolstered by further examination of the individual code findings.

A second matrix query was run to cross-reference positive perceptions of CS with pedagogical design elements. The results of this query are presented in Table 35 below with 135 cross-references across the entire matrix:

	Collaboration	Constructivist	Creativity	Faciliator and Student Relationship	Learning Environment	Presentation	Problem Solving	Skills	Social Learning protocols	Visual
Better understanding	1	1	0	2	1	0	0	1	1	0
Enjoyable	22	2	7	7	4	2	6	0	9	0
Fun	6	1	2	5	7	1	0	3	8	1
Gender	0	0	0	0	0	0	0	0	0	0
Interesting	2	2	1	4	6	1	1	1	8	0
Lack of prior experience	1	1	0	1	0	0	1	0	1	0
Stereotypes	0	0	0	0	0	0	0	0	0	0
Useful skills	1	0	0	1	1	0	0	0	1	0

Table 35: Positive CS Vs Pedagogical Approach Matrix

Two rows yielded no cross-referenced results (gender, stereotypes). The most populated rows were enjoyable (n=54), fun (n=34) and interesting (26). The most populated cell was that of enjoyable vs collaboration which yielded 22 results:

"I thought I wouldn't enjoy this program but I enjoyed it a lot working with my group and creating pretty good animations and games"

"I enjoyed being able to do new and fun things with new people as a team and would like to learn more about programming."

"I really enjoyed my time here and I loved being part of the programme. I really enjoyed my team and I feel like I've become closer to the girls from my school and also made forever friends. Thank you so so much!".

Social learning protocols was the second most populated of the columns (n=28), after collaboration (n=33):

"I was interested it was very inclusive, I had a lot of fun too."

"The learning experience was really good. The teachers helped us a lot and taught us coding really well and was able to understand it. We did cool and fun projects too."

"The team (staff) were very helpful and interactive, they also gave us fun activities to help us learn more about coding and technology."

"I really enjoyed it. Found it very interesting. Everyone was so helpful and nice. I learned a lot."

The facilitator and student relationships (n=20) and learning environment columns (n=19) yielded similar numbers of cross references:

"*It was a very fun an interesting experience and to get to go to Trinity College everyday for a week was an amazing opportunity and I'd love to do it again."*

"I liked the whole vibes around the workshop, and I learnt a lot of new things it really sparked an interest in me."

"I had fun, it was better than school and I liked my team."

"I thought it was a great opportunity to learn about coding. I discovered some things I wouldn't have learned in school."

"I loved the workshop because I have an interest in computers and the people that worked there are really nice. I loved meeting new people and working together."

"The mentors were great help in showing me how to code, especially since I have never code before.

A matrix query was run to cross-reference negative and maths related perceptions of CS with pedagogical design elements. The results of this query are presented in Table 36 below:

	Collaboration	Constructivist	Creativity	Faciliator and Student Relationship	Learning Environment	Presentation	Problem Solving	Skills	Social Learning protocols	Visual
Maths	1	0	1	0	0	0	0	0	0	0
Boring	2	1	0	0	1	0	0	0	1	0
Difficult	2	0	0	0	0	0	0	0	0	0
Frustrating	2	0	0	0	0	0	1	0	0	0
Not interested	3	0	0	0	0	0	0	0	0	0
Unrealistic	0	0	0	0	0	0	0	0	0	0

Table 36: Negative & Maths Perceptions of CS Vs Pedagogical Approach Matrix

The overall results yielded a small number of cross-referenced results (n=15), with one row (unrealistic), and a number of columns (FSR, presentation, problem solving, skills, visual) yielding no results. The collaboration column was the most populated (n=10):

"I enjoyed the teamwork but at times it did seem boring. I'd like there to be more brainstorming as a group because everyone could have interesting ideas."

"Some people in my team have done programming before but I never, I found some difficulties during the process."

"I find teams that don't control annoying and Frustrating."

"Because I thought working in a team would be more exciting and because I thought I would be more interested in IT."

While these findings taken from the results of the matrix query suggest negative sentiments, it is interesting to note upon reading that a number of the segments were in fact qualifying a negative aspect of the intervention with an indication they found the collaborative learning element positive. For example:

"Some parts were boring and I would get frustrated. However, I really enjoyed the games + animations. I liked working in a team +meeting new people."

"I enjoyed working with my group but I didn't love the programming."

"No. I like that even though I'm not very interested for computer, but that give me more mathematics thinking and more team work chances"

This is an interesting example of the limitations of the Nvivo matrix query function, that while certainly a useful tool in isolating data for further examination, caution must be taken to read the data and consider the context in which it is retrieved. The findings that cross-reference the pedagogical elements of the intervention with perceptions of CS suggest that aspects of the pedagogical approach affected some positive (for the most part) perceptions of CS for participants.

A final matrix query was run to cross-reference the pedagogical design elements with the "future intentions" generic sub-category. The results of this query are presented in Table 37 below:

	Collaboration	Constructivist	Creativity	Facilitator and Student Relationship	Learning Environment	Presentation	Problem Solving	Skills	Social Learning protocols	Visual
Just not for me	0	0	0	0	0	0	0	0	0	0
Motivation to learn more	6	0	1	2	5	0	0	0	1	0
Neg_Intentions	0	0	0	0	0	0	0	0	0	0
Pos_Intentions	0	0	0	0	1	0	0	0	0	0
Unsure	0	0	0	0	1	0	0	0	0	0
Just not for me	0	0	0	0	0	0	0	0	0	0

Table 37: Future Intentions Vs Pedagogical Approach Design Matrix

The overall results yielded a small number of cross-referenced results (n=17), with two rows (just not for me, negative intentions), and a number of columns (presentation, problem solving, skills, visual) yielding no results. The "motivation to learn more" row was the most populated (n=15) with motivation to learn more vs collaboration cell the most populated (n=6):

"I think that another workshop could help further my knowledge of programming and help with team work."

"I would be interested because I would learn more skills and have the ability to work with other."

One comment of interest stated a wish to return but with another team:

"Because I want to do more and see what we can do and understand more. It was to short. I want to try with an other team [Sic]."

The next most populated cell was motivation to learn more vs learning environment (n=5):

"I liked the whole vibes around the workshop, and I learnt a lot of new things it really sparked an interest in me"

"I would love to participate in other workshops. I have done code plus now and bridge 21 and I enjoyed it both times and it educated me in a way not available in school which I think is very beneficial to me and I would love to get the opportunity to participate in another project."

Somewhat related to learning environment, social learning protocols (n=1) and facilitator and student relationship (n=2) vs motivation to learn more yielded some insightful segments:

"I want to learn more and I think it would be better while having people guide you in the right direction."

"I feel like I would like to do this again they didn't push me to do thing I didn't wanna do."

While the instances of cross-referencing between the pedagogical design elements and future intentions were relatively small, that segments above would suggest that several aspects of the pedagogical design positively affected a motivation for the participants to learn more.

6.4.2.3 All-female Environment

Both theoretical and empirical literature have advocated for all-female environments as a means to foster greater interest and peer-support for girls and women in exploring CS pathways. Based on this practice, the CodePlus intervention design utilized an all-female environment, something which was unique in comparison to other Bridge21 learning interventions which are co-educational. It is important to note that while every effort was made by the programme team to recruit female volunteers and casually paid "mentors", there were several male adults that worked on the programme over the duration of the research project. The author took programme lead from 2016 onwards and ran the majority of workshops as facilitator with support from a second female colleague, in short, the workshops were led by women and any male volunteers or paid mentors took more deferential roles.

Two codes relating to the all-female environment were included in the intervention design coding matrix under the parent-code "all female environment". These codes were initially named "female peers" and "role models". These were changed during the analysis of the data to "meeting new people" and "speakers". The rationale for the first change was that the author found participants were typically not directly referencing the element of working with other female peers or girls, but rather mentioned meeting new people as an enjoyable and worthwhile aspect of the workshop. An Nvivo memo below illustrates the author's thoughts on this during the analysis of qualitative data:

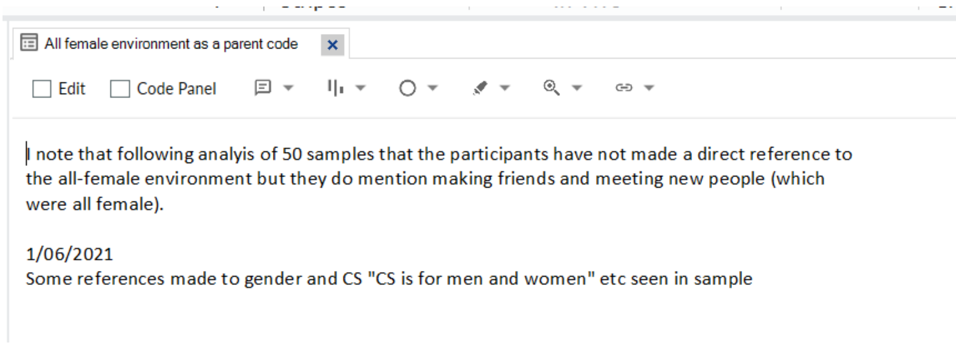


Figure 29: Memo "All-female Environment Parent Code"

The role model code was changed to “guest speakers”, which was a more accurate code name for an element of the intervention that the participants were describing. From 2017 onwards the author introduced “career panel” talks into the 4-day intervention whereby female professionals would come and speak to the participants for 30-45 minutes about their college and CS career experience and take questions. This code is distinctly different in its operationalisation to “facilitator and student relationships” or “social learning protocols” in that it specifically mentioned the guest speakers (all of whom were female). A second memo shows the author considering potential cross-overs by categorization:

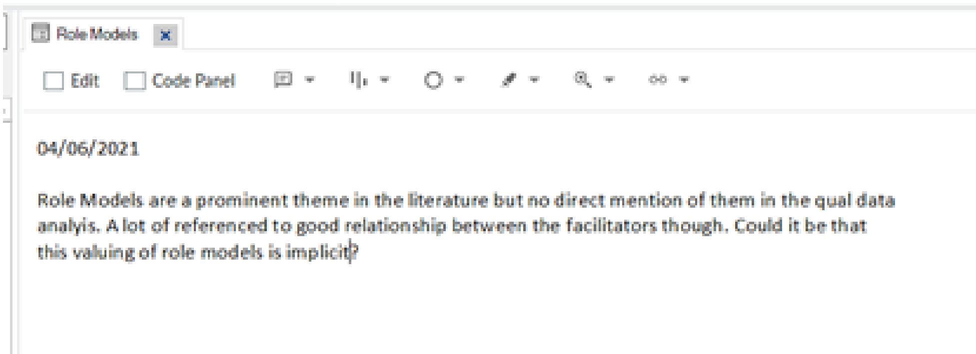


Figure 30: Memo “Role Models"

Table 38 below presents the occurrences of the two codes by sentiment:

Code	Sentiment	Occurrences
Meeting new people	Pos	114
	Neg	2
Guest Speakers	Pos	9

Table 38: All-Female Environment Codes

Occurrences of the “meeting new people” code were predominantly positive (n=114), either identifying that aspect of the intervention as enjoyable or reflecting on working with new people as an accomplishment:

“I really enjoyed the programme and making new friends from different schools.”

“I can work well with new people.”

“I learned that I can work freely with people I don't know.”

“I think it was good that we were mixed up in our group as it meant we got to work with new people.”

There were just two negative sentiment comments:

“*Try have at least one person in your team that you know.”*

“Maybe leave schools together.”

The 9 “guest speaker” coded segments were positive in sentiment, referencing the value of that element of the programme:

“I learned a lot from the experience of professor Lucy.”

“made new friends, learned about coding and Google where they gave us motivation and told us things we wouldn't hear anywhere else.”

“That listening to peoples story can be really interesting, and that it can influence me, especially as a girl.”

Table 39 below shows the results of a matrix coding query run to cross reference the self-efficacy effects codes with the all-female environment codes:

	Meeting new people	Guest Speakers
Computer SE	0	0
Other SE	6	0
Programming Ability	1	0

Table 39: Self-Efficacy Vs All-Female Environment

The “guest speakers” column yielded no results. The “meeting new people” column yielded 7 results, with “other SE” the most populated cell:

“I am and can be more confident when around people who are equally just, the girls made the experience more enjoyable because we were all friends. There was no room to feel anxious especially in the setting.”

“Because I met a lot of people and I learned new things that I never had known before. Communicating with people made me confident.”

The “programming ability” cell yielded one result, which appears to make two separate points on programming ability and making friends and is therefore not an example of the matrix coding query function returning a segment that meaningfully links the two codes:

“I feel that by learning the basics of coding, I have convinced myself that I could possibly make a game in the near future I also enjoyed making friends with others and socialising.”

	Meeting new people	Speakers
Better understanding	0	0
Enjoyable	0	0
Fun	1	0
Gender	0	0
Interesting	0	0
Lack of prior experience	0	0
Stereotypes	0	0
Useful skills	0	0

Table 40: Positive Perceptions of CS Vs All-Female Environment

The results of a matrix coding query positive perceptions of CS Vs all-female environment are presented in Table 40. Just one result was found:

"I had a lot of fun and learned so much. I also got to meet new people and got a little more out of my comfort zone."

A query run to return cross-referenced segments of the negative and maths perceptions of CS codes Vs all-female environment returned no results.

A final query run to return cross-referenced segments of the future intentions codes Vs all-female environment also returned no results.

In summary, the all-female code queries did appear to return positives results, particularly with the participants' reference to peers and the element of meeting new people during the programme. Matrix coding queries that cross-referenced the intervention effects with the all-female environment codes returned limited results.

It interesting to note how very few direct references were made to peers being exclusively female. There are a number of possible explanations for this; either the participants did not consider the all-female element of the intervention's design as particularly important, or that the participants' appreciation of an all-female peer environment was more implicit in nature. It is worth noting that a large proportion of the participants came from single-sex schools and were likely to have been familiar with working in all-female peer environments. As the study was situated in the context of a working outreach programme, creating a "control" mixed-gender group to compare results was neither practical nor feasible. This question will be brought to the next stages of the study in the longitudinal data and is an interesting avenue for further research.

6.4.2.4 Technology Used

Chapter 4 (Design), describes the multiple elements that contributed to the design of the learning intervention and composite activities. This includes a justification of the choices and sequencing of programming languages, with particular reference to a constructivist learning pedagogy supported by visual programming languages (Resnick et al., 2009).

As detailed in Chapter 4, the CodePlus intervention worked off the assumption that most participants were novice programmers and the graphical programming language Scratch served as their introduction to coding, moving on to the text-based language Python later in the week. The programme also included sessions centred around computer hardware kits (MakeyMakey, Arduino, Rasberry Pi, micro:bit) and a suite of computational thinking and problem solving activities adapted from the CS Unplugged Programme resources(Taub, Ben-Ari, & Armoni, 2009).

As the choice of technology used was a considered design element of the programme, pre-determined codes were developed for the directed content analysis and included in the "Intervention Design" categorisation matrix under the parent code "technology used". The individual codes were; scratch, python, unplugged and hardware.

These codes emerged frequently from the written survey data as presented in Table 41 below, with Scratch the most commonly occurring, followed by Python.

Code	Sentiment	Occurrences
Scratch	Pos	96
	Neg	33
Python	Pos	65
	Neg	22
Unplugged	Pos	15
Hardware	Pos	4

Table 41: Technology Used Codes

Segments that referenced Scratch were generally of positive sentiment (n=96) and could be further categorised by references to learning Scratch or enjoyment of using Scratch:

"I never used scratch before and this way my first time so using it was very fun."

"I learnt a lot about coding using Scratch and I think that it will come in useful, I am definetely considering doing more coding courses in the future."

There were 33 codes of negative sentiment which could be further categorised by a general dislike of scratch or preference for python over scratch.

"I hate scratch"

"It was very enjoyable but some of the scratch I didn't enjoy."

“Scratch is really not my thing and although I try to be patient with it I just can't and I find it really boring and stressful.”

“I think that the course should include more difficult programming languages such as python as opposed to scratch.”

“We learned about scratch but I would like to learn more on phython [Sic].”

“I learn better when there are less moving parts (python was easier than scratch).”

Section 4.3.3 details how Python was introduced to the workshops in 2017/18 following preliminary reading of the written survey data and other feedback from participants and teachers. The Python code featured frequently in analysis of the written survey data. Most of the segments were of positive sentiment (n=65) and comprised of references to enjoying python, learning python and preferring python to scratch:

“I like the python yoke.”

“I would love to work more with Python and develop my skills.”

“I enjoy python more than scratch”

“A lot of scratch was done, which wasn't my favourite whereas I enjoyed python more.”

“Personally, it could've been faster but that would be unfair to others. I know a lot of people wanted to do more python and similar coding sooner.”

Segments with a negative sentiment (n=22) either referenced the difficulty of python, a dislike of python or were critical of the style in which Python was taught:

“I enjoyed scratch but I did not like python”

“I found scratch very enjoyable however python wasn't so great”

“I found that learning Python was quite difficult and I think that it would have been better if we had more of an introduction.”

“I found python very confusing and a little bit unenjoyable. Maybe if they explained how to use python I would've known what I was doing”

I thought it was great in many ways, especially with scratch, the LEDs and analouges but I felt that Python was a step too far and it really stressed me out.

Interestingly, there were several comments on approach to teaching Python in the intervention. As detailed in Section 4.3.3, this activity used the “Python from Scratch” resources developed by Byrne et al. (2015b), which linked core programming concepts in Python to code that the participants had previously encountered with Scratch earlier in the week. One segment indicated that this was a helpful approach:

“Having the codes written in scratch helped me understand python”

Others did not find the approach helpful:

“I feel like python should not be converted into scratch because it was very difficult and I never completed it”

“Explain Python better instead of giving us a sheet and telling us what to do instead of how to do”

All references to the “unplugged” activities were positive (n=15) with participants indicating that they were enjoyable or useful in terms of learning concepts in CS:

“I really liked the puzzles and riddles etc. put more those!”

“I learned that I enjoy thinking problems as the ones we did on Thursday with the cards and the bomb.”

“More engaging games like the card game where you put it in an order or where you fill a jug up to 4kg. It got my mind thinking and was really interesting.”

“I found that learning how to think like a computer really helped me to understand how a computer works.

!I learned that I learn really quickly when we do different activities before the tasks e.g; allow the activities we did on the boards.”

The small number of references to the “hardware” code were all positive in sentiment (n=4), with several participants indicating that they preferred this aspect of the workshops over others:

“thought it was great in many ways, especially with scratch, the LEDs and analouges”

“prefer to do a more hands on coding ie. Robotics”

A matrix coding query was run to cross-reference the self-efficacy codes with the “technology used codes”. Table 42 below presents the results of the query:

	Hardware	Python	Scratch	Unplugged
Computer SE	0	1	3	0
Other SE	0	0	0	1
Programming Ability	1	12	27	0

Table 42: Self-Efficacy Vs Technology Used

The “Other SE” row returned the least amount of cross-referenced codes (n=1), followed by “Computer SE” (n=4):

I learned that I learn really quickly when we do different activities before the tasks e.g; allow the activities we did on the boards” (Other SE vs Unplugged)

“Learning about programming i.e python has given me more confidence in my computer skills but I know this is extremely basic programming” (Computer SE vs Python)

“I can actually manage to do something with the computers, like Scratch” (Computer SE Vs Scratch)

The “Programming Ability” row was the most heavily populated (n=40):

“I'm alright at scratch” (Programming Ability Vs Scratch)

“I'm decent at programming on scratch” (Programming Ability Vs Scratch)

“I am good at scratch and I can now create games” (Programming Ability Vs Scratch)

“Before this week, I wasn't great at coding now I feel a lot better at it and I enjoyed using Python even though it was hard. It's helpful.” (Programming Ability Vs Python)

“Being introduced to Python didn't seem as daunting as I thought and I hope to explore the language more since it doesn't seem that difficult.” (Programming Ability Vs Python)

“Because it taught me a lot of things like how to do scratch a bit better and the phyton [Sic] and microbits” .” (Programming Ability Vs Hardware, Scratch, Python)

A second matrix coding query was run, cross referencing the “positive CS” perception codes with the “technology used” codes. Table 43 below presents the results of the query:

	Hardware	Python	Scratch	Unplugged
Better understanding	0	0	2	1
Enjoyable	0	15	15	1
Fun	0	2	5	0
Gender	0	0	0	0
Interesting	0	2	2	1
Lack of prior experience	0	2	2	0
Stereotypes	0	0	0	0
Useful skills	0	2	2	0

Table 43: Positive Perceptions of CS Vs Technology Used

Several rows returned no results (Gender, Stereotypes) and one column (hardware). The “better understanding” row returned 3 results:

“I learned more about what goes on behind the scenes of programming a computer & video games. I learned this by creating a game on Scratch.” (Better Understanding Vs Scratch)

“I found that learning how to think like a computer really helped me to understand how a computer works.” (Better Understanding Vs Unplugged)

The “useful skills” and “lack of prior experience” rows both returned 4 results in the same scratch and python cells:

"Since we did python I found it more interesting and engaging before I would never even think of coding" (Lack of Prior Experience Vs Python)

"I never used scratch before and this way my first time so using it was very fun" (Lack of Prior Experience Vs Scratch)

"I learnt a lot about coding using Scratch and I think that it will come in useful, I am definetely [Sic] considering doing more coding courses in the future (Useful Skills Vs Scratch)

The "interesting" row returned 5 results:

"I'm really interested in the gaming we did on scratch." (Interesting Vs Scratch)

"I would like to come back as I was very interested in the coding language and python etc I would like to learn more about it." (Interesting Vs Python)

"More engaging games like the card game where you put it in an order or where you fill a jug up to 4kg. It got my mind thinking and was really interesting" (Interesting Vs Unplugged)

The "fun" row returned 7 results:

"I learned that working with scratch is really fun." (Fun Vs Scratch)

"found learning how to make games very fun and enjoyed trying out new things like python" (Fun Vs Python)

One segment returned was negative in sentiment towards the instruction in python and coding but mentioned that the group games were fun:

"It was alright. I really like scratch. I just wasn't taught much. No one explainesd how to use python or did an example. I didn't learn that much on coding. The group games were fun." (Fun Vs Python)

The most populated row was "enjoyable" (n=31), with mostly positive sentiment:

"I enjoy coding and I liked learning to use python."

"I really enjoyed learning how to use scratch and making the animation and game. I also really enjoyed trying to figure out the problems."

"I really enjoyed making the animations and the game fun- it was creative and personal.

"As much as I found python a little head-wrecking I still enjoyed it- I loved problem solving. -enjoyed the whole week especially programming on scratch and Python"

Interestingly, a number of the segments returned in this query specified enjoying some of the technology over others:

"It was very enjoyable but some of the scratch I didn't enjoy. I preferred the card game and problem solving parts"

"I found scratch very enjoyable however python wasn't so great"

"I enjoyed the animation on scratch but didn't find the python coding that fun"

A third matrix coding query was run, this time cross referencing the negative and maths perceptions of CS and the technology used. The results of this query are presented in Table 44 below:

	Hardware	Python	Scratch	Unplugged
Maths	0	0	0	0
Boring	0	0	4	0
Difficult	0	9	4	0
Frustrating	0	0	4	0
Not interested	0	0	1	0
Unrealistic	0	1	4	0

Table 44: Negative Perceptions of CS Vs Technology Used

One row returned no results (maths) and one column (hardware). The "not interested" row returned 1 result which was in fact indicating interest only in Scratch:

"*CodePlus programme but I only really liked Scratch and I am not that interested in doing more computer programming."*

The "boring" and "frustrating" rows returned 4 results in the same Scratch cells:

"Scratch is very frustrating."

"*I think scratch is a good way to learn but it is a bit boring and stressful"*

"Scratch is really not my thing and although I try to be patient with it I just can't and I find it really boring and stressful."

The "unrealistic" row returned 5 results, all indicating that Scratch was not considered "real programming":

"I thought we'd actually learn how to do proper programming and not just use scratch"

"We didn't do anything more difficult than scratch, I didn't feel that it reflected college level computer science."

"I think that the course should include more difficult programming languages such as python as opposed to scratch. Using more difficult programms [Sic] *would give a better idea of what college computer science is like."*

The most populated row was “difficult” (n=13), with all but one reference indicating that learning python was difficult, “hard” or “confusing”. Although this code was included in the “negative perceptions” of CS branch code, the author considers that the returned segments were for the most part only moderately negative:

“Scratch is difficult”

“Python was REALLY hard.”

“We got to learn how to use scratch and how to make an animation, but it was kind of confusing when we learned python language.”

“I was hoping to learn a good basis on the world of coding. I feel like it will really help me but I did find python very hard. Overall though I found it a very enjoyable experience and I'm very grateful to have done it.”

A final matrix query was run to cross-reference the technology codes with “future intentions”. The results of this query are presented in Table 45 below:

	Hardware	Python	Scratch	Unplugged
Just not for me	0	1	1	0
Motivation to learn more	0	10	0	0
Neg_Intentions	0	0	0	0
Pos_Intentions	0	2	2	0
Unsure	0	0	0	0

Table 45: Future Intentions Vs Technology Used

Two rows returned no results (neg_intentions, unsure) and one column (hardware). The “just not for me” row returned 2 results, one segment indicating an interest only in scratch and the other suggesting that working more with python would make the programme better for those interested:

“CodePlus programme but I only really liked Scratch and I am not that interested in doing more computer programming.”

“Nothing it would be amazing for people who are interested. Just a bit more working with python.”

The positive intentions row returned 4 results:

“Because I loved using python and im considering it as a career.”

“I learnt a lot about coding using Scratch and I think that it will come in useful, I am definetely considering doing more coding courses in the future”

The “motivation to learn more” row returned the most results (n=10), all in the Python cell:

“After this experience I would like to learn more about python”

"I would love to get to know more about Python and other computer languages as I've really enjoyed the introduction"

"I would like to practice more advanced coding so that I can understand python and similar coding languages"

In summary, the technology queries did appear to return positives results, particularly with the participants' reference to the activities being fun, enjoyable or worthwhile. The emergence of personal preferences from analysis of the data was apparent, for example those who preferred python to scratch and vice-versa.

Matrix coding queries that cross-referenced the intervention effects with the technology used suggested a number of theories. As one may expect, technology and programming ability were strongly linked. There were also more positive perceptions of CS linked with the technology used than negative and more positive future intentions.

The appetite for moving from Scratch onto Python as a "real" coding language emerged as a theme from the data, which affirms to decision to introduce that element into the workshops following its earlier practice. The relative difficulty of Python was also referenced, while for some "a step too far", those noting the challenge was not always entirely negative in their sentiments.

It is also interesting to note how Scratch is seemingly not afforded the same status as a programming language among the participants although it is widely regarded as a fun and enjoyable way to program. There may be a number of explanations of this, primarily the nature of Scratch itself as a graphical (non-text) language, and the age range of Scratch's core user base as 9-13[52]. Many of the participants may have been introduced to Scratch in primary or early secondary school, or have been familiar with CoderDojo workshops who use Scratch frequently and are generally comprised of younger children. These factors may have influenced perceptions of Scratch as less authentic or "babyish" by comparison to text-based languages and would be an interesting avenue for further research.

Based on the findings reported from analysis of the qualitative data, it can be argued that the separate elements of the technology used in the intervention did contribute to providing authentic and stimulating CS learning activities. The considered choice of technologies used played a key role in achieving this goal.

The following section will examine improvements to the programme that participants suggested when given the opportunity to comment.

6.4.2.5 Improvements to Programme

The final question on the written survey invited participants to add "Any other comments or suggestions to improve the programme?"

The codes within this parent were all inductively derived from analysis of the data and revised throughout the process. The final list of codes and their occurrences are presented below in Table 46 with a total of 177 coded segments collected.

[52] https://scratch.mit.edu/statistics/

Code	Occurrences
No Improvements	66
More Programming Languages	33
More Instruction	30
Make Intervention Longer	30
Make Intervention Shorter	2
Too Easy	8
Too Hard	5

Table 46: Improvements to Programme

Many participants took the opportunity to effectively praise the programme by stating they would suggest no improvements as presented in Table 46 above. These segments (n=66) comprised of very simple "no" or "nope" statements, segments that indicated enjoyment of the programme, praise for the team, or how the programme was organised:

"Nope"

"Nope. Perfect"

"Nah lads you're all very chill"

"Stay the same and stay fabulous"

"I don't really have any improvements since the programme is an excellent taster for beginners. I really enjoyed my time here and wish to be back soon. Thank you to all the leaders and for this amazing programme."

A number of segments (n=33) indicated a desire to learn more coding languages. Most of the segments further indicated text-based or "real" programming languages. Unsurprisingly the majority of these segments were codes in the pre-2018 data set (n=23) when the Python activity had not yet been introduced to the programme:

"include a wider variety of programming apps used."

"think we should start coding on the first day. I also think we should have learned a bit more coding languages like java"

"Spend less time on scratch and be taught more about coding languages e.g. java, python etc (I still don't know what they are)."

"Personally, it could've been faster but that would be unfair to others. I know a lot of people wanted to do more python and similar coding sooner."

30 segments indicated an opinion or wish that the course should be longer. These responses ranged from direct suggestions of "making it longer", to statements indicating that the course was too rushed, to segments that effectively praised the course by stating a sadness it had finished:

“Make it longer (2-3 weeks)”

“I wish we were here for longer :(I'm going to miss everyone so much”

“No suggestions, other than I felt the program was quite rushed.”

“This workshop was so good but I feel like it was too short to get more knowledge and ideas about computer programming”

In contrast, 2 segments expressed a wish for the programme to be shorter:

I think it's very good, but it can be less days”

“That maybe if it was possible you could make it a day course rather then 4 overall. It was good. Thanks for Everything.”

A number of segments (n=8) indicated finding aspects of the programme too easy or “basic”:

“It was fun and everyone there was lovely but the coding was quite basic”

“We didn't do anything more difficult than scratch, I didn't feel that it reflected college level computer science.”

“I think that the course should include more difficult programming languages such as python as opposed to scratch. Using more difficult programms [Sic] *would give a better idea of what college computer science is like.”*

In contrast, 5 segments indicted that aspects of the programme were too hard (n=5):

“Make it easier?”

“Just ease a bit on the Python”

“Maybe introduce students with easier tasks? Other than that I had a brill time”

In summary, responses to this question further confirmed previous findings that the course has been an enjoyable and worthwhile experience for participants. The main improvements suggested by participants to the course were to bring in more text-based coding languages, make the activities more challenging, and make the course longer. These findings can be considered positive to a large degree in that they indicate an appetite for more challenging content and a longer engagement. During the course of the study the programme was adjusted to include the Python activities in response to initial reading of the qualitative survey data which indicated a desire to move on to text based languages. It’s not surprising given the sample size that by contrast, a number of participants found aspects of the course difficult, particularly the text-based coding. The programme was advertised to schools and students as an introductory course in CS and programming suitable for complete beginners or for those with a little prior experience. As stated earlier in this chapter, the author and the programme team had very little control over the selection of students from schools which meant that pitching the level of challenge was an educated guess. During the programme weeks, every effort was made to adjust the level of difficulty in activities to suit teams and individual participants where appropriate as described in Section 4.3.3. The findings reported in this section would suggest that the course in its format was acceptable to the majority of students, with some valid rationale given for a longer course with a greater degree of text-based programming languages.

6.5 Analysis of Short Term Data Summary

The quantitative and qualitative findings presented in this chapter provide evidence of both the short-term effects of the intervention and an exploration of how elements of the intervention's design contributed to these effects. To that end, the researcher considers that RQs 1 and 3 have been addressed:

> Research Question 1: What is the short-term effect of the intervention's approach?
>
> Research Question 3: How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term change?

Each research question was further expanded to guide the analysis. With regard to RQ1:

> a) Did the intervention affect significant short-term changes in key-attitudinal variables such as computer self-efficacy and perceptions of CS?
>
> b) Did the intervention affect significant short-term changes in intentional variables such as careers and college pathways?
>
> c) What were the significant relationships between the measured variables?

With regard to RQ3 qualitative data enabled the researcher to either confirm or to contradict the findings of the quantitative data and explore a set of sub-questions thus:

> a) How did the pedagogical design aspects of the intervention affect short-term outcomes?
>
> b) How did other design aspects of the intervention (all-female environment, college location etc.) affect short-term outcomes?
>
> c) Are there other factors emergent in the data that contribute to girls' predilections towards (or away from) career and college pathways in computer science?

The research aims specific to the short-term element of the study were:

1. To assess the short-term impact of the intervention
2. To gather and analyse data on role of pedagogy in the design of the intervention
3. To develop a structured framework for assessing the short-term impact of computer science outreach programmes for girls
4. To generate relevant questions for future research

As shown in the analysis of data, the above objectives were met. Results of the quantitative data analysis were positive and indicated significant short term improvements in computer self-efficacy, perceptions of CS and future intentions regarding CS pathways. The qualitative data allowed for a triangulation of these findings which gave further validation to the quantitative results.

The analysis of qualitative data strongly suggests that the design elements of the intervention contributed to the observed effects. Results were most prominent concerning the pedagogical design aspect of the intervention, in particular the collaborative and constructivist learning methods that are central to the Bridge21 learning model. Other design elements such as the all-female learning environment were less distinct and warrant further analysis in the next stage of the research.

The author considers that are a number of limitations factors concerning these findings that should be taken into account. Foremost, given the practitioner-based nature of the intervention as a working outreach programme, the opportunistic sampling of participants is an area of concern, but the author does consider that this is somewhat mitigated by the large sample size and number of schools (n=55) represented in the demographic. While prior levels of interest, perceptions and motivation concerning CS are difficult to isolate and ultimately programme places were allocated by teachers, questions in the quantitative instrument did explore for such variables pre and post-intervention.

Secondly, as an example of a pre-experimental design the research study did not provide a control group as in a quasi or true experiment. This author argues that creating such a control group would not have been feasible, appropriate or ethical in this context.

Finally, the data collected at this stage of the study is entirely based on the participants' self-reporting. Participants were neither observed nor given standardised tests to assess their programming ability pre and post-intervention for instance. The author does consider that this factor is somewhat addressed by the application of a mixed methods approach to triangulate and enhance the reliability of the data, reporting on results that contradict the general trends and hypotheses, and presenting qualitative data within appropriate sampling units to convey the authentic voice of participants. The author also considers the abstract nature of the key attitudinal and intentional variables that were measured in terms of self-efficacy, perceptions and intentions which arguably could only be attained through self-reporting.

The limitations outlined above are not uncommon to pragmatically-based educational research. They do not however, suggest that the findings are not suitable for generalisation, or that they do not form potentially valuable contributions to the field. In this context, many of the findings from the short-term analysis of data could inform either in-school or other CS outreach activities and thus go further than an evaluation of the programme described in the intervention.

7 Longitudinal Data Findings and Analysis

7.1 Introduction

The longitudinal aspect of this study was designed in response to a key criticism of the CS outreach space showing a lack of studies that evaluate the enduring effects of intervention programmes (Section 3.5.4). In the context of this study there was an opportunity to survey a sample of the research cohort at a time when they would be making third level applications, approximately two years following participation in the intervention. The number of participants choosing to pursue courses related to computer science was a statistic of obvious interest in this regard, but given the multitude of factors that affect vocational choices, both antecedent and mediating variables would also need to be investigated. For participants who were *not* electing to study CS or a related course, it was also important to ask whether or not the intervention had helped to make a more “informed decision” in this regard. Establishing the factors outside of the influence of the programme that affected this decision would also be of interest.

Longitudinal studies are appealing in their ability to “establish causality and make inferences” (Cohen et al., 2007) and it was hypothesised that there would be multiple factors outside of the intervention itself that would influence an individual’s predilection towards or away from CS pathways. A number of these factors could be anticipated, such as family and peer influences, exposure to CS, and personal interest. To begin to isolate and unravel these factors, including that of the intervention effect itself, the author would use the longitudinal element in an attempt to “catch the complexity of human behaviour” (Ruspini, 2002). In addition to the survey, a number of interviews with participants could explore the causal effect of the intervention in the context of a broader narrative.

While both numerical and qualitative data can be combined in a longitudinal study, Cohen et al. (2007) advise that how and when data collection occurs should be informed by both fitness for purpose and practicality. A key challenge of longitudinal studies are factoring in attrition rates, on that basis it is advisable to begin with as large as sample as practical at the outset (Wilson et al., 2006). Initially, this study had a large sample (n=856) making a longitudinal element viable.

This chapter describes the instruments, analysis procedures, and findings from the longitudinal stage of the research study. As in the approach of the short-term phase, the collection and analysis of data was quantitatively led with an embedded element of qualitative data to further explore these results. A survey instrument designed by the author and interviews were used to collect the data. Figure 31 below illustrates this phase of the study in the context of the overall mixed-methods design strategy:

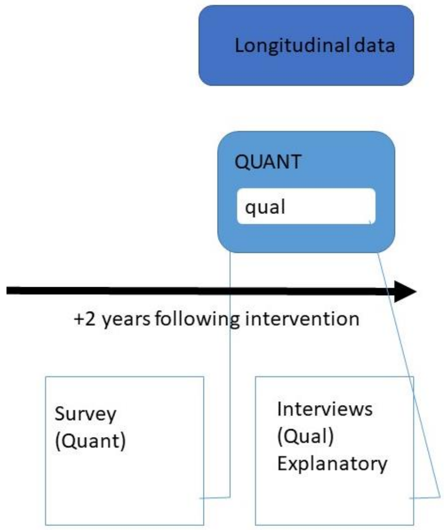


Figure 31: Longitudinal data diagram illustrating nested mixed methods design

The findings of this stage of study suggest that the intervention was a key influence for a number of participants in electing to study a CS or related course. This is inferred both from data that directly investigates the effect of the intervention and contextual data that highlighted the limited external CS resources and supports available to participants. The survey data (n=75) provides a general picture of this landscape in quantitative terms whilst the interview data (n=4) provides individual rich narrative accounts in which the impact of the intervention and other factors can be explored. In particular, the quantitative survey results suggested that both the programme workshops and career talks programmes aided participants in making an informed decision as to whether or not they would be interested in pursuing a CS related third level course, and attending advanced CS workshops with the Bridge21 and CodePlus programmes were significantly associated with applying for CS related third level courses. The interview data supported many of the quantitative data findings and offered deep perspectives on the impact of the programme in the context of other factors and influences.

7.2 Research Aims and Questions

The research aims specific to the longitudinal element of the study were:

1. To examine the effect of the intervention against the multifaceted and complex factors that influence predilections to study computer science or related pathways.
2. To identify areas for further research.

The longitudinal stage of the study addressed RQs 2 and 3:

Research Question 2: What are the longitudinal effects of the intervention?

Research Question 3: How did particular elements of the intervention's approach, design, and pedagogical considerations affect short-term and longitudinal change?

Each research question was further expanded to guide the analysis. With regard to RQ2:

RQ2a) Was participation in the intervention a factor in deciding whether to apply for CS or related third level courses?

RQ2b) What other key factors contributed to deciding whether to apply for CS or related third level courses?

RQ2c) To what extent can the intervention's longitudinal effect be meaningfully assessed against other factors?

These sub-questions could be posed given the quantitative, prescriptive nature of the data collected and the subsequent suitability of such data for statistical analysis techniques.

With regard to RQ3, the qualitative, rich textual data collected enabled the researcher to either confirm or contradict the findings of the quantitative data and explore a set of sub-questions thus:

RQ3a) How did the pedagogical design aspects of the intervention affect longitudinal outcomes?

RQ3b) How did other design aspects of the intervention (all-female environment, college location etc.) affect longitudinal outcomes?

RQ3c) Are there other factors emergent in the data that contribute to girls' predilections towards (or away from) career and college pathways in computer science?

7.3 Context: The CAO Application and Third Level

Collecting longitudinal data required access to participants at least two academic years following participation in the programme. As detailed in Chapter 4, participants took part in the programme during the 4th “transition year” of secondary school and two years later most were preparing for the final state examinations (leaving certificate). In the lead up to their final examinations students begin the process of college and third level applications through the Central Applications Office (CAO)[53]. Preliminary applications are made in February for choice of course and institution however applications can be amended up to mid-July with offers for places from the third-level institutions made in August based on examination results.

Contacting students once they have left secondary school is inherently difficult, for this reason the data was confined to two academic years; the graduating classes of 2019/20 and 2020/21. Furthermore, the return rate of the survey was largely dependent on the support of teachers who circulated the link to students and sent reminders. The Covid19 pandemic caused huge disruptions and closures to the schools during this time which impacted on the return rates. Ideally, this data collection would have taken place within the schools and supervised as per the short-term surveys, as but as this was not possible the survey link was sent remotely.

The longitudinal survey tool was designed to capture the CAO preferences of participants in order to examine the number of students choosing to study CS or related courses. It was also designed to investigate the factors that influenced participants in choosing courses and what impact the CodePlus programme had (if any) in these choices.

In addition to gathering survey data, the author interviewed four previous programme alumni who were all either studying or in one case applying to study CS. This was an opportunistic sample in that the four interviewees were known to the author through participation in the CodePlus programme and had responded to a request sent out to programme participants now studying or intending to study CS to be interviewed for the study,

It was intended that these interviews could serve as rich, qualitative texts that could expand on the findings of the quantitatively-led survey data.

[53] http://www.cao.ie/index.php

7.4 Data Collection and Analysis

The longitudinal element of the research took a mixed methods approach with a quantitative lead. In this approach, a survey was first used to gather categorical and ordinal data[54] centred on the participants third level choices and influencing factors. The nested, qualitative data was used to triangulate the findings of the quantitative data in an explanatory capacity, whilst also offering an opportunity to explore and uncover emergent themes. The design of both methods used and details of analysis and findings are presented in the following sub-sections:

7.4.1 Longitudinal Survey

The longitudinal survey instrument was designed to measure the longitudinal impact of the programme within the context of the multiple factors affecting participants in choosing college pathways. The survey was designed based on a review of empirical and theoretical data (Chapters 2 and 3), and the results of the short-term analysis. The survey was designed and hosted via the Qualtrics software application and distributed to participants via their given email details. A copy of the survey is provided in Appendix D.

The survey consisted of 5 question groups:

1. Demographic and Contact Information

This consisted of biographical information such as name, DOB, and school name. Participants were also invited to update contact details if they chose to, so that they could be invited to participate in interviews.

2. Intentions Concerning Third Level Education

Participants were asked to indicate their intentions regarding third level education and which broad subject area courses (arts, social sciences, education etc…) they had applied to. Participants were then asked to indicate in order of importance which factors influenced their applications for college courses.

3. Computer Science, Computing and Related Courses

Participants were asked to indicate whether or not they made any applications to courses involving computer science, computing, computer engineering, or IT. Participants could indicate which courses they had applied to and were asked to indicate in order of importance which factors influenced their applications for CS related courses. The categories of factors influencing participants to apply or not to apply for CS related college courses were adapted from Papastergiou (2008).

[54] While the survey predominantly consisted of closed variables, in some questions respondents had the option to type an alternative

4. Computing Outreach (Outside of CodePlus) and Role Models

Participants were asked to indicate whether they had engaged in other CS outreach programmes in the past 2 years (CoderDojo, library Courses, afterschool clubs etc.). Participants were also asked to indicate if they had family members, friends, or others they would describe as a role models studying or working in the area of computer science, computer engineering, computing, or IT. These role model categories were further categorised by gender (mother, father, male teacher, female teacher etc.). Finally, participants were asked to indicate if Computer Science was an elective subject option in their school for the leaving certificate examinations, whether they had actually taken the subject and if they would have taken it given the option.

5. CodePlus Experience and Evaluation

The final set of questions concerned the participants' experience regarding the CodePlus programme. Details of participants' involvement, such as if they had received a career talk or attended the advanced programme weeks were recorded. Participants were asked to evaluate particular aspects of the programme's design with regard to helping them decide whether or not they would be interested in studying a computer science, computing, or IT related course. Participants were also asked to indicate their level of agreement with a number of statements concerning adequate experience to make an informed decision concerning third level computer science courses.

7.4.2 Longitudinal Survey Results

Participation in the longitudinal survey was entirely voluntary on the part of participants and as anticipated there was considerable attrition rate from the cohort of students who had completed the short-term survey (n=340). 75 participants completed a longitudinal survey from the 2019/20 and 2020/21 academic year cohorts[55] making approximately 22% of the original demographic. According to Bartlett, JW, and Higgins (2001, p. 48), 85 is the cut-off point for a representative sample size taken from a population of 300 (alpha=0.5) concerning continuous data, with categorical data requiring a cut off of 169. To that end, it was unlikely that those who remained in the study were as representative of the original 340 as a larger sample would have been and thus results should be accepted with caution.

Data collected from the survey was analyzed using the SPSS software package using summary and descriptive statistics.

The findings from the survey will now be presented in the aforementioned survey categories:

1. Demographic Information

The respondents could be categorised by 16 individual schools. The data was collected over a two-year period from with 28 students from the 2019/20 academic year and 47 from the 2020/21 academic year.

[55] It was not possible to collect longitudinal survey data from previous cohort years 2015-2018

2. Third Level Education

93% (66 valid) respondents indicated their intention to enrol in third level education. 4 respondents indicated that they were unsure and just one indicated that they did not intend to enrol. Table 47 below presents the number of respondents and the corresponding percentage of whom had applied to study broad course subjects[56] in descending order. These were not selected by respondents in any order of preference (more than one category could be selected), but to give a general picture of which areas of study participants had applied to:

Subject Area	**Number of Respondents**	**Percentage (to nearest whole number)**
Arts and humanities	20	27%
Business, administration and Law	15	20%
Natural sciences, mathematics and statistics	14	19%
Social sciences, journalism and information	13	17%
Other	11	15%
Information and Communication Technologies (ICTs)	10	13%
Health and welfare	9	12%
Education	6	8%
Engineering, manufacturing and construction	6	8%
Agriculture, forestry, fisheries and veterinary	2	3%
Services	0	-
Generic programmes and qualifications	0	-

Table 47: Third level subject areas chosen by respondents

11 respondents selected "other", 7 of whom specified the areas of study as "art, "art and design", "biomedical science", "culinary" [Sic], "nursing, dna and forensics", psychology, and "science/ computer science/ data science". 10 students indicated ICTs.

When asked to select in order of importance which factors influenced respondents most in choosing a third level course, strong personal interest in the subject area was rated as most important by the most respondents (32%), followed by a future with guaranteed employment (17%). Table 48 below presents the factors and percentage of respondents that rated the factor as most or second most important. Respondents that indicated "other" factors included; "ability to travel with job", "Flexibility", "I just want to do a course that looks actually enjoyable to learn", "I like biology", "I get on great with children", "It had practical work", "My own school experience", "progression to

56 These categories were taken from the Higher Education Authority (HEA) fields of study in Ireland https://hea.ie/

masters/phD", "Requirements for certain jobs", "Teachers in my school have influenced me to aim for a Job as a second level educator" and "Tried out the profession through work experience".

Factor	Rated most important	Rated 2nd most important
A future with guaranteed employment	17%	15%
Someone in my family has influenced me through their experience in the area	26%	11%
Strong personal interest in subject area	32%	15%
Well-paid jobs in the area	6%	31%
Secondary school experience with subject	9%	22%
Other	9%	6%

Table 48: Factors influencing choice of third level subjects

3. Computer Science, Computing and Related Courses

When participants were asked to indicate whether or not they had applied to study any course or courses related to computer science, computer engineering, computing, or IT, 16[57] respondents (25%) indicated yes and 49 (75%) indicated no from 65 valid responses. Table 49 below presents the number of respondents indicating that they had applied to each college course, participants could select more than one course:

[57] This number contradicts the finding from Table 47 where 10 participants indicted applying for ICTs. The author believes that this can be explained by some respondents considering ICTs as distinct from Computer Science and Computing.

Course	**Number of Participants**	**Course**	**Number of Participants**
Computer Engineering level 6 (higher certificate)	1	Computer Science level 8 (higher degree)	6
Computing level 6 (higher certificate)	1	Computer Games Development level 8 (higher degree)	2
Computing and Multimedia level 6 (higher certificate)	1	Computing in Interactive Digital Art and Design level 8 (higher degree)	0
Electronic and Computer Engineering level 6 (higher certificate)	1	Cloud Computing level 8 (higher degree)	0
Computing level 7 (ordinary degree)	2	Business Computing level 8 (higher degree)	3
Information Technology level 7 (ordinary degree)	0	Computer Networks and Systems Management level 8 (higher degree)	2
Business and IT level 7 (ordinary degree)	0	Electronic and Computer Engineering level 8 (higher degree)	3
Computing in Interactive Digital Art and Design level 7 (ordinary degree)	0	Applied Computing level 8 (higher degree)	0
IT Management level 7 (ordinary degree)	0	Computing with Language level 8 (higher degree)	2
Computing with Games Development level 7 (ordinary degree)	1	Computer Science and Business level 8 (higher degree)	1
Computing level 8 (higher degree)	2	Other	5
Psychology and Computing level 8 (higher degree)	0		

Table 49: Breakdown of CS, Computing and ICT third level courses chose

“Computer Science” was the most popular choice with 6 respondents indicating that they had chosen that course, “Business Computing” and “Electronic and Computer Engineering” were the second most popular choices with 3 respondents. 5 respondents indicated that they had applied for other courses which were named as “Arts in Maynooth but I plan on choosing computer science as my option”, “Creative Digital Media”, “Cyber security” and “General science: biology/chemistry/ computer science/ data science”.

For respondents who had indicated that they had chosen to apply to any courses related to computer science, computer engineering, computing, or IT, they were asked to select in order of importance which factors influenced respondents most in choosing any these courses. “A future with guaranteed employment” emerged as the highest rated factor (42%).While 13% of respondents selected “other” factors, these factors were not specified when prompted:

Factor	**Rated most important**	**Rated 2nd most important**
A future with guaranteed employment	40%	7%
Someone in my family has influenced me through their experience in the area	20%	40%
Strong personal interest in subject area	20%	20%
Well-paid jobs in the area	7%	27%
Secondary school experience with subject	0%	7%
Other	13%	0%

Table 50: Factors influencing respondents to choose CS and related courses

For respondents who had indicated they had not chosen to apply to any courses related to CS, they were asked to select in order of importance which factors influenced them most in not choosing any of these courses. “Preference to study other subject(s)” was rated as most important by the most respondents (56%). Table 51 presents the factors and percentage of respondents that rated the factor as most or second most important. While 2% of respondents selected “other” factors, these factors were not specified when prompted:

Factor	Rated most important	Rated 2nd most important
Preference to study other subject(s)	56%	4%
Dislike of computers and preference towards more people-based professions	7%	47%
Studying Computer Science or working in the IT profession seems too difficult	9%	18%
Lack of prior opportunities to get involved with computers in the home or school environment	8%	18%
Unemployment in the profession	20%	11%
Other	2%	2%

Table 51: Factors influencing respondents to not choose CS and related courses

4. Computing Outreach (Outside of CodePlus) and Role Models

When asked to indicate if they had engaged with any CS outreach programmes apart from CodePlus in the past 2 years, 46 respondents indicated no. Table 52 below presents a breakdown of CS outreach activities and the number of respondents to each category. When asked to specify any other unprompted activities the following responses were provided; "Coding", "I study computer science", "NCI Ctrl-Alt-Compete", "UCD innovation course, iwish, UCD science sparks".

Engagement with other outreach programmes in past 2 years	Number of Respondents
None	46
CoderDojo	3
Library Courses	1
After-school or lunchtime clubs	3
CS Summer Camps	4
Other	6

Table 52: Engagement with CS outreach outside CodePlus

Respondents were asked to select all relevant family members, friends or someone they would describe as a role model studying or working in the area of computer science, computer engineering, computing or IT. Table 53 below presents a breakdown of different male and female role models. In all comparative categories more respondents indicated male role models. The author created three new variables from the data, the first recording whether a respondent had indicated having any female role models from the list, the second recording whether a respondent had indicated having any male role models from the list, and the third recording any male or female role model. It was found that 12 respondents had indicated having one or multiple female role models, 33 respondents had indicated having one or multiple male role models and 46 participants indicted having at least one male or female role model.

9 participants indicated “other” role models and when asked to specify their relationship to the person the following responses were provided: “Brother in law”, “Grandad”, “I don’t have any”, “Mothers friend”, “my brothers friend”,“no one”, “No one”, “no one in my family”.

Female Role Models	**Number of Respondents**	**Male Role Models**	**Number of Respondents**
Mother	3	Father	5
Sister	2	Brother	4
Aunt	1	Uncle	11
Female Cousin	1	Male Cousin	3
Female Friend	5	Male Friend	9
Female Teacher	2	Male Teacher	8

Table 53: Male and Female CS Role Models

Respondents were asked to indicate on a scale of 1-4 (1=No positive encouragement, 4=A lot of positive encouragement) to what extent they had received encouragement from family, friends, teachers, and “others” to study a computing related course. The mean scores for each category were compared and presented in Table 54 below with highest mean recorded for family. When asked to specify other sources of encouragement respondents wrote: “A co-worker”, “classmates”, “Counsellor”, “Mentors from outreach programmes such as Codeplus”, “People running courses”, “Random people that I wouldn’t consider my friends, more like an acquaintance e.g. a random adult u meet at a gathering ur parent dragged u to”, “Strangers/Internet friends”.

Sources of Encouragement	**Mean Score**	**Standard Deviation**
Family	2.65	1.1
Teachers	2.6	.97
Friends	2.22	1.04
Others	2.29	1.19

Table 54: Encouragement to study CS and related courses

When asked whether or not Computer Science was offered as Leaving Certificate subject in their school at the time they had entered 5th year[58], 58 responses were given. Of these responses 13 said yes, 44 said no and 1 respondent selected “I’m not sure”.

Of those who had responded that CS was offered as a Leaving Certificate Subject in their school, 5 respondents indicated that they had taken the subject, 2 indicated that they had not, and 1 respondent indicated that she had taken the subject but dropped out of the class before the exam.

Of those who had responded that CS was not was offered as a Leaving Certificate Subject in their school, respondents were asked if they would have taken the subject had the option been available. 16 responses indicated yes, 16 indicated no, and a further 13 indicated that they were not sure.

5. CodePlus Experience and Evaluation

Respondents were asked to select a level of agreement from 1-5 (1=strongly disagree, 5=strongly agree) with several statements concerning adequate experience to make an informed decision concerning third level computer science. The percentages of respondents indicating agree and strongly agree are presented in Table 55 below:

[58] The Irish Senior School Cycle is two years in duration, thus any leaving certificate curriculum subjects are generally taken in 5th year

Statement	Strongly Agree	Agree	Cumulative
I have had enough experience with computer science, coding, and programming to make an informed decision as to whether or not I would like to study a related third level course	31%	35%	66%
My experience with the CodePlus workshops helped me to make an informed decision as to whether or not I would like to study a related third level course	20%	56%	76%
My experience with the CodePlus career talks helped me to make an informed decision as to whether or not I would like to study a related third level course	26%	42%	68%

Table 55: Personal Experience Statements

Respondents were asked to indicate whether they had attended additional coding workshops with Bridge21 and CodePlus besides the introductory workshop. 11 respondents indicated that they had participated in the CodePlus advanced workshop and 6 respondents indicated that they had participated in the Invent week workshops, 2 respondents indicated attending both.

Respondents were asked to rate on a scale of 1-4 (1=had no value, 4=very valuable) how valuable particular aspects of the CodePlus workshops were in terms of helping decide whether or not they would be interested in studying a computer science, computing, or IT related course. The percentages of respondents indicating very valuable and valuable are presented in Table 56 below:

Workshop Element	Very Valuable	Valuable	Cumulative
Learning in an all-female environment	32%	32%	64%
Learning in teams	33%	33%	66%
Activities and projects related to real-world problems	36%	42%	78%
The mentors/helpers	39%	39%	78%
Understanding more about careers in computer science and computing	39%	45%	84%
Receiving encouragement to explore careers and study in the area of computing	27%	50%	77%

Spending time on the Trinity College campus	39%	39%	72%

Table 56: Workshop Elements Value Ranking

Respondents were given the opportunity to respond with “I’m not sure” in each of the above categories, 3 respondents selected this for “learning in an all-female environment”, 1 for “learning in teams”, and 1 for “activities and projects related to real-world problems”.

Respondents were asked to indicate whether they had attended a CodePlus career talk workshop from a woman or women working in the tech industry either in school, at the college, or at a tech company in the past two years. 21 respondents indicated that they had attended an in-school talk, 16 indicated they had attended a talk at a tech company and 13 students attended a talk within the college.

A final set of questions asked participants to rank how valuable aspects of the career talks were in terms of helping them decide whether or not they would be interested in studying a computer science, computing, or IT related course. Each aspect was ranked on a scale of 1-4 (1= had no value, 4=very valuable). The percentages of respondents indicating valuable and very valuable are presented in Table 57 below:

Statement	Very Valuable	Valuable	Cumulative
Getting to meet a female role model in the industry	33%	47%	80%
Understanding more about careers in computer science and computing	40%	54%	94%
Learning about the variety of jobs in the industry	51%	43%	94%
Learning about the advantages of working in the industry	32%	56%	88%
Visiting a tech company	45%	36%	81%

Table 57: Aspects of Career Talks Value Ranking

To test for potential associations of interest between categorical variables, a number of chi-square tests of independence were performed. Applying for CS related courses was investigated for association with the following:

- School availability of Leaving Certificate computer science
- Taking computer science as a Leaving Certificate elective
- Participating in additional CS outreach activities
- Taking additional CodePlus Workshops
- Having a female role model or rolemodels studying or working in the field
- Receiving a career talk

Regarding the school availability of Leaving Certificate and applying for a CS related third-level course, a chi-square test showed that there was no significant association between the two variables:

X^2 (1, N = 57) = .172, p = .678

A second chi-square test showed that there was no significant association between taking computer science as a leaving certificate and applying for a CS related third-level course:

X^2 (2, N = 13) = .660, p = .719

Considering the small sample of respondents who had indicated their school offered computer science as a leaving certificated elective was small (n=13), this may not have provided a sufficient sample size to establish a true pattern of association with regard to the two test results reported above.

A third chi-square test showed that there was no significant association between engaging in additional CS outreach activities (outside of CodePlus) and applying for a CS related third-level course:

X^2 (1, N = 65) = .702, p = .402

A fourth chi-square test showed a significant association between engaging in additional workshops (CodePlus advanced week and/or Invent week and applying for a CS related third-level course. This was the only chi-square test in the analysis of the longitudinal survey data that returned a significant association:

X^2 (1, N = 65) = 5.110, p = .024

Concerning specific male and female role models, separate chi-square tests were run to check for an association between a respondent indicating the role model and applying for a CS related third-level course. No significant association was found. With three new variables created from the data; at least one female role model, at least one male role model, and at least one male or female role model further chi-square tests were performed but no significant association was found. The results of these tests are presented in Table 58 below:

Role Model Variable	**Chi-Square Test Result**	**Conclude**
At least one female role model	X^2 (1, N = 65) = .001, p = .973	No significant association
At least one male role model	X^2 (1, N = 65) = .418, p = .518	No significant association
At least one male or female role model	X^2 (1, N = 65) = .042, = .838	No significant association

Table 58: Chi-square tests of association between role models and applying for CS course

A final chi-square test was run to check for an association between attending a career talk and applying for a CS related course. No significant association was found:

X^2 (1, N = 65) = .184, p = .668

7.4.3 Discussion of Longitudinal Survey Findings

The results of the quantitative analysis presented go some way in answering Research Questions 2(a), 2(b) and 2(c):

> RQ2(a) Was participation in the intervention a factor in deciding whether to apply for CS or related third level courses?

The results presented in Table 55 show that 76% of respondents either agreed or strongly agreed with the statement "My experience with the CodePlus workshops helped me to make an informed decision as to whether or not I would like to study a related third level course", and 68% of respondents either agreed or strongly agreed with the statement "My experience with the CodePlus career talks helped me to make an informed decision as to whether or not I would like to study a related third level course". This can be considered as a fundamentally positive finding of the survey whether participants were electing to follow pathways in computer science (or not) as it was a key objective of the programme to enable participants to make an *informed choice* based on their experience during the intervention regardless of actual college preferences.

Two value-statement results in Table 56 give further support to these findings, where 84% of respondents indicated that "Understanding more about careers in computer science and computing" was a valuable or very valuable aspect of the workshops and 77% of participants indicated that "Receiving encouragement to explore careers and study in the area of computing" was a valuable or very valuable aspect of the intervention. A greater level of understanding of, and receiving encouragement to explore the field are key themes in the theoretical and empirical literature around bridging the gender gap in CS (See Chapters 2 and 3) with the potential to greatly impact the participation of young girls and women. The author considers that these findings are encouraging given in the context of this study and would likely be applicable to similar initiatives.

56 respondents indicated receiving at least one career talk either in school, at a company, or in the college through the programme. Table 57 shows a number of encouraging results. In particular, 94% of respondents indicated that "Understanding more about careers in computer science and computing" and "Learning about the variety of jobs in the industry" were valuable or very valuable aspects of the career talks. These were encouraging findings that support the case for including a career talks element in the programme and the argument that such practices can hold value for providing CS exposure to girls (Frieze, 2005; Hunter & Boersen, 2017). A chi-square test showed no significant association between attending a talk and applying for a CS related third-level course, however the test may have also been affected by the modest sample size.

Results specific to evaluating aspects of CodePlus workshops and talks were encouraging, indicative of high value that placed on the activities (Table 56, Table 57). All aspects of the programme workshops were rated valuable or very valuable by over 64% of respondents while all aspects of the programme talks were rated valuable or very valuable by over 80% of respondents. These findings are supportive of the considered design elements of the intervention; learning in teams, activities linked to real-world problems, an all-female environment etc. The design elements of the workshops and speaker programmes were based on findings in the literature review (See Section 2.6)

The significant association between the 15 respondents who had participated in additional coding workshops with the programme (CodePlus advanced or InventWeek or both) and applying for a CS related third-level course was a key finding of the survey. This could indicate that a deeper level of engagement is required for greater lasting impact, but it is also very possible that students who attended additional courses may have been generally more interested in applying for CS in college.

Overall these findings support an argument for the programme having an impact on the respondents in deciding whether to apply for CS related third level courses or not. It was interesting to note that the career talks workshops and workshops were closely weighted in terms of value by respondents. This raises a question on the value of career talks as a more economical and scalable intervention measure than running intensive workshops. The sparse landscape of female role models available to the sample presented in Table 53 may also shed light on this finding. Finally, the survey did not ask participants to choose *between* the workshops and talks in terms of which element of the programme was most helpful in deciding whether or not they were interested in studying CS. It is likely that *both* elements were helpful as the findings suggest and investigating the impact of a career talks programme in its own merit would be a useful avenue for future study.

The following questions RQ2(b) and RQ2(c) examine other key factors and to what extent can the intervention's impact be measured against these factors:

> RQ2 (b) What other key factors contributed to deciding whether to apply for CS or related third level courses?

16 respondents indicated that they had applied to at least one CS related course. For these respondents Table 50 explored the factors that had influenced them in order of importance: "A future with guaranteed employment" emerged as the highest rated factor (42%), "Someone in my family has influenced me through their experience in the area" and "Strong personal interest in subject area" emerged jointly as the second most commonly rated highest factor (20%). These results are comparable to those of Papastergiou (2008) who found that the prevalent reasons both boys and girls elected to study CS followed the following order of preference:

1 Profession of the future with guaranteed employment
2. Strong personal interest in computers (favorite hobby) since childhood
3. Well-paid jobs

Interestingly Papastergiou found that only boys had ranked "profession of father/brother" as a motivating factor in her study, this factor was modified in the context of this survey to "someone in my family has influenced me in the area" and was the factor most frequently ranked second by level of importance (40%).

For the respondents who had indicated that they were *not* applying to any CS related courses, Table 51 explored the factors that had influenced them in order of importance: "Preference to study other subject(s)" emerged predominantly as the most commonly rated highest factor (56%) followed by "Unemployment in the profession" (20%). The author considers a preference to study other subjects an understandable and highly personal motivation that is beyond the parameters of this study to investigate in further detail. In support of this argument, Table 47 reflects the broad spectrum of subject areas the respondents had applied to. It was interesting to note however that "Dislike of computers and preference towards more people-based professions" was the factor most frequently ranked second by level of importance (47%).

These results are interesting to compare to those in the Papastergiou study:

Papastergiou found that reasons for both boys and girls not intending to study CS were ranked in the following order:

1. Other professional plans
2. Dislike of computers and preference towards more people-based professions
3. Difficulty of CS studies and the IT profession
4. Lack of prior opportunities to get involved with computers in the home or school environment[59]
5. Unemployment in the profession

In the context of this study's survey, "Preference to study other subjects" is comparable to "Other professional plans". It is also interesting to note that the factors "Studying Computer Science or working in the IT profession seems too difficult" (9% 1st, 18% 2nd), and "Lack of prior opportunities to get involved with computers in the home or school environment" (8% 1st, 18% 2nd) were almost ranked equally. These results are comparable to those of the Papastergiou study. Furthermore, Papastergiou found that girls are more negatively influenced than boys by the perceived difficulty of CS and the IT profession and the percentage of girls who reported a lack of prior opportunities to get involved with computers in the home or at school was significantly higher than the respective percentage of boys. Interestingly, Papastergiou found that boys were more likely to be dissuaded from CS by unemployment than the girls, but this was also the least commonly cited factor across both genders. In this study, "Unemployment in the profession" was the factor that was most frequently ranked first (20% of participants) after "Preference to study other subjects" (56%). This finding is a cause for concern that may reflect some respondents' lack of exposure to information regarding careers in technology, a field in which job opportunities continue to grow rapidly, not least in an Irish context. It may also raise a question on the enduring impact of the intervention in presenting computer science as a field with secure employment, given that these participants ranked unemployment in the profession highly as an influencing factor. It is interesting to note that this finding is at odds with those who were electing to study a CS related course, where "A future with guaranteed employment" emerged as the highest rated

[59] This finding may be indicative of age of study (2008), as more recent research points to girls and boys having equal access to computers (Ofcom, 2015).

factor. Could it be the case that those interested in pursuing CS pathways have a more accurate awareness of employment in the field than those who do not? This would be an interesting avenue for further research.

Table 54 presented the results of a set of questions where respondents indicated to what extent they had received encouragement from family, friends, teachers and "others" to study a computing related course. The mean scores for each category were between 2.65 and 2.22. Further visual inspection of histograms showed that the "friends" category had a bimodal distribution, with the 34% of respondents indicating either having had "no positive encouragement" or "reasonable positive encouragement". This is an interesting finding that points to some significant deviation on the part of the sample in terms of peer support, this can be further considered in relation to research linking gender peer support with girls' STEM and CS career motivation (Cohoon & Aspray, 2006; Master, Cheryan, & Meltzoff, 2016; Robnett & Leaper, 2013).

Based on the findings presented above, that there were multiple factors outside of the intervention's influence that contributed to respondents deciding whether to apply for CS or related third level courses. The following question will examine the impact of the intervention against other key factors.

> RQ2(c) To what extent can the intervention's longitudinal effect be measured against other key factors?

In Table 55, the statement "I have had enough experience with computer science, coding, and programming to make an informed decision as to whether or not I would like to study a related third level course" received a high level of agreement where 66% of respondents agreed or strongly agreed with the statement. It is important to note that this statement could include experience outside of the programme, and further questions were asked to establish school and other CS outreach exposure.

In establishing which other (if any) CS outreach activities the participants had engaged in apart from CodePlus in the past two years, it was found the majority of respondents had engaged in none (46). Small numbers ($n<6$) had indicated engaging in various different programme types. A chi-square test showed no significant association between engaging in additional CS outreach activities (outside of CodePlus) and applying for a CS related third-level course. This question may have highlighted a potential lack of opportunity for the respondents, although it could also indicate a lack of interest in engaging in such programmes. The author proposes that given the participants had sufficient interest to engage in the CodePlus programme in the first place, a lack of opportunity may be more likely to the main cause. It would be useful for further research to catalogue other CS programmes available to adolescent girls rather than to rely on participants self-reporting of these resources and to map the areas which are underserved in this regard. It would also be useful to examine other barriers to joining such as cost and distance and to look at how such programmes are advertised. One obvious question to ask is would girls be more likely to join all-female initiatives over mixed-gender if they were offered the choice?

Concerning the availability of computer science as a leaving certificate course just 13 respondents indicated this was an option available to them, of this group 5 indicated actually taking the subject. This low number is unsurprising given that at the time of this data collection only 40 schools in Ireland were offering this option. It was interesting to note that a further 16 respondents indicated that they would have taken the subject for the leaving certificate had the option been available to them. This means 28% of respondents either took or would have taken the subject indicating an appetite within the cohort for the CS elective. Chi-square tests showed that there were no significant associations between applying for a CS or related course and school availability of leaving certificate CS or actually taking leaving certificate CS. While no significant associations were found, the results of the chi-square test concerning an association between a desire to take computer science as a leaving cert elective (if offered by the school) and applying for a CS related third-level course were *approaching* significance: X^2 (2, N = 45) = 5.485, p = .064. Although limited in the sample size of respondents who had the option and those who subsequently took the option, these findings are encouraging in a number of ways and support an argument for more schools to adopt the CS leaving certificate curriculum.

Overall, 46 respondents indicated having at least one male or female role model studying or working in the area of computer science, computer engineering, computing, or IT. There was a considerable difference between the number of respondents that indicated having at least one male role model (33) and the number of respondents that indicated having at least one female role model (12). It was interesting to note that across all comparable categories, there were a greater number of male role models indicated by respondents. These findings highlight the lack of female role models available to girls, a key theme in the literature concerning gender imbalance in the field (Barker & Cohoon, 2006; Margolis & Fisher, 2002; Spertus, 1991), although chi-square tests showed no significant association between a respondent having either at least one male, female or either gendered role model and applying for a CS related third-level course. It would be interesting to explore this with a larger sample size to establish if role models (male or female) are as significant an influence pertaining to improving the gender balance in CS as the literature suggests.

Exploring factors outside of the programme such as additional outreach activities, access to leaving certificate CS and access to female role models were anticipated mediating factors. It was clear from the findings that there were shortfalls in terms of the respondents' exposure to these resources. As a result of low baseline levels of exposure and engagement with these categories, the sample may have been insufficiently large enough to establish significant patterns of association with applying for CS related third level courses. Nonetheless, the findings from Table 52 and Table 53 and those concerning the limited availability of leaving certificate computer science support the case for interventions such as CodePlus in terms of providing exposure that girls may not otherwise receive.

It is difficult to isolate in absolute or deductive terms the effect of the intervention against confounding and mediating variables. It is perhaps more appropriate to infer the effect of the intervention in a more inductive manner as discussed above, as Cohen et al. (2007, p. 56) writes: "In an interconnected world of multiple cases and causal nets, conditions and interactions may provide better accounts of causation than linear determinism." The results from this analysis influenced the design of the qualitative interview protocols which would provide an opportunity to explore the casual effects of the intervention through a narrative.

There were a number of limitations associated with the longitudinal survey findings that the author fully acknowledges. Primarily, the sample size was small relative to the short-term survey and thus did not lend itself to powerful statistical analysis procedures. Secondly, the sample was an opportunistic, as opposed to a randomised true population sample. It is possible that those who had elected to answer the survey were more likely to be applying to CS related courses, it is also possible and indeed probable that there are other CodePlus alumni electing to study CS that the survey did not catch. These are limitations that affect many studies with a longitudinal element. In spite of these limitations, the survey did return some interesting findings that warrant further investigation and a framework for future studies that may have the benefit of a larger sample size. The findings also offer some directions for the design of the interviews, which will be discussed in the following section.

7.4.4 Qualitative Data Collection (Interviews)

Qualitative data analysis involved individual interviews all with participants who had applied to or were pursuing third level courses related to computer science. Four individual interviews, each lasting between 30 and 45 minutes in duration were conducted with participants comprising roughly 2.25 hours of data.

In Chapter 5 (Methodology) the merits of interview as a qualitative tool were briefly discussed in terms of enabling participants to give their perspectives on situations and phenomena. When interview is used in conjunction with other methods, it can be used to validate findings or to go deeper into the motivations of participants (Kerlinger, 1970). Indeed, the interview itself is comparable to a questionnaire, however the interview has some distinct advantages such as greater opportunities for personalisation and probing that a questionnaire does not accommodate as easily (Tuckerman, 1972).

In the context of this study, interviews could provide a means to further examine key factors influencing college pathways that emerged from the short-term phase and longitudinal survey. As discussed in the previous section it is difficult to isolate causes from effects in absolute terms and it is more likely that there are multiple and complex causes at play. Cohen et al. (2007, p. 58) writes; “It is rare to find a single cause of a single effect. It is more often the case that there are several causes at work in a single situation and that these produced a multiplicity of effects”. By using interview these causes and effects could be unravelled through careful design and interview techniques. With this approach, each interview was designed to assess the longitudinal effect of the intervention against the landscape of multifaceted motivations, supports and other contributory factors. Respondents were asked to speak about how they had decided to apply for computer science related courses, to describe the school and outside school CS activities they had engaged in, to recall their experience of the CodePlus programme and finally to speak about the reasons for gender-imbalance in the field based from their own perspective.

Interview planning was based on Cohen et al. (2007, p. 425)’s guidelines for interview conduct, considered in light of conducting the interviews by video conferencing software, for example great care was taken to maintain appropriate eye contact with participants. Offering participants a chance to speak “off the record” following the interview was also helpful as a debriefing exercise which all interviewees made use of. An interview protocol sheet was prepared in advance of the interviews (Table 59 below) and provided a guiding structure with margins for note taking.

Main Question	Additional Qs/Prompts	Clarifying Qs
1. Can you tell me a little about where you are in terms of your own school and college journey?	• Courses you've applied for • Colleges you've applied to • College Year • Internships	
2. How did you decide on what courses to apply for?	• Diversity in types of course • Non CS Courses • Did you change your mind or were you very set? • Biggest factors to consider when choosing	Why? How?
3. How did you come to include CS in your choices?	• What influenced you? • Biggest factors • Role models and encouragement • When did you decide you were going in that direction?	Can you expand on that? Could you give some examples?
4. Can you tell me a bit about your school and CS?	• LC subject? • After School Clubs • Programming in JC/TY • Peers and CS	
5. Can you tell me a bit about any other clubs or CS activities you were involved with? **(Not CodePlus)**	• Clubs/Dojos • Self-Taught? • Other B21 (not CodePlus)	

<table>
<tr><td>6. What can you remember about your experience at CodePlus?</td><td>Extra weeks
Pedagogy
All-female environment
Speakers
Company Visit</td><td rowspan="2">Why?

How?

Can you expand on that?

Could you give some examples?</td></tr>
<tr><td>7. What would you say were the main benefits for you, being a part of the programme?</td><td>Different to other influences?
Anything you would have changed about or that would have made it better?
What do you think the programme is trying to achieve and does it?
All Female</td></tr>
<tr><td>Additional: What do you feel are the reasons so few girls consider CS Pathways?</td><td>Experience
Perceptions
Confidence
What could be done?</td><td></td></tr>
<tr><td colspan="3">Conclusion of Interview
Check interpretations

“Can I just check if my understanding is correct?”

Would you like to add anything to what you’ve said already?

Would you like to ask any questions about the research or your data?

Would you like to say anything “off the record” (stop recording)</td></tr>
</table>

Table 59: Interview protocol sheet

7.4.5 Qualitative Data Analysis

7.4.5.1 Selecting Coding Methods

There is no single or correct way to analyse qualitative data, rather the analysis should be guided by a "fitness for purpose " approach (Cohen et al., 2007). By adopting this principle, a researcher should be clear in the purpose of the data analysis as this will determine the nature of the analysis undertaken. Regarding the choice of coding methods, Saldaña (2013) recommends aligning the research question(s) with suitable strategies; "The nature of your central and related research questions and thus the answers you seek will influence the specific coding choices you make". Section 7.2 gives details of the research questions pertaining to the longitudinal element of the study, where qualitative data collected would to either confirm or to contradict the findings of the quantitative data and also explore a set of sub-questions thus:

> RQ3(a) How did the pedagogical design aspects of the intervention affect longitudinal outcomes?
>
> RQ3(b) How did other design aspects of the intervention (all-female environment, college location etc.) affect longitudinal outcomes?
>
> RQ3(c) Are there other factors emergent in the data that contribute to girls' predilections towards (or away from) career and college pathways in computer science?

In the context of this study, the analysis of qualitative data in the short-term and longitudinal phase were markedly different. The short-term data was analysed using directed content analysis (DCA) in order to triangulate the quantitative findings and indeed to further explore potential causal relationships between the design elements of the intervention and its effects. A large sample size (N=418), and the relatively short nature of the units of analysis (usually one to several sentences) lent itself to quantifying the content analysis. While this approach was appropriate for the short-term survey data, it was not applied to the analysis of interviews. Primarily, there were far fewer sampling units (four individual interviews), that comprised of much more data to analyse. It was considered that in this context "frequency of occurrence is not necessarily an indicator of significance" (Saldaña, 2013), and significance could be found by more interpretively led methods. The narrative nature of the interviews would provide a source of rich text from which "to ponder, to scrutinize, to interrogate, to experiment, to feel, to empathize, to sympathize, to speculate, to assess, to organize, to pattern, to categorize, to connect, to integrate, to synthesize, to reflect, to hypothesize, to assert, to conceptualize, to abstract."(Saldaña, 2013, p. 39).

People tend to naturally produce narratives in interviews so that their experience can be given a temporal coherence or chronology. By identifying key actors and events, "turning points" or "epiphanies" are established by the narrator which can include a variety of themes (Gibbs, 2018, p. 99). Based on the narrative nature of the data and the alignment of the research aims and questions, the author chose two coding methods; Holistic and Causation coding.

Holistic Coding

Holistic coding is an attempt "to grasp basic themes or issues in the data by absorbing them as a whole (the coder as 'lumper') rather than by analysing them line by line (the coder as 'splitter')" (Dey, 1993, p. 104). The method is a preparatory and exploratory approach to a unit of data before a more detailed coding or categorization process through further First or Second Cycle methods (Saldaña, 2013, p. 142). Holistic Coding is suitable when the researcher already has some general idea of what to investigate in the data, or "to 'chunk' the text into broad topic areas, as a first step to seeing what is there" (Bazeley, 2007, p. 67). Holistic coding is particularly applicable to "self-standing" interview data in which participants describe episodes of their story (Saldaña, 2013). The author considered this an appropriate initial approach for the coding of the interview data to get a sense of the overall themes across the corpus.

Causation Coding

Causation Coding involves extracting attributions or causal beliefs from participant data particular by searching for combinations of antecedent and mediating variables that lead toward certain pathways (Saldaña, 2013). Causation Coding attempts to label the mental models participants use to uncover "what people believe about events and their causes (Munton, Silvester, Stratton, & Hanks, 1999). In Causal Coding, an attribution has three elements: the cause, the outcome and the link between the cause and the outcome (Munton et al., 1999, p. 9), this model can be further conceptualised by the documenting of antecedent, mediating and outcome variables (Huberman & Miles, 1994) or by mapping a three-part process as CODE 1 > CODE 2 > CODE 3 (Saldaña, 2013).

While Saldaña (2013) writes that Causation Coding is appropriate for establishing motives and exploring "why" questions, he cautions that this method is not an infallible means of deducing the true cause of an effect. Rather the method is a heuristic for exploring what the plausible causes and potential outcomes are in particular cases.

The author considered this method highly appropriate given the purposes of the analysis to establish the longitudinal effects of the intervention and its design elements against the multifaceted factors that affect college pathway choices.

7.4.5.2 Coding Process

Data analysis in most qualitative research begins during data collection (Ezzy, 2002). In the context of this study, the author considers how "preliminary jottings" (Saldaña, 2013) and memos were taken during the interviews and written in the margins of the protocol sheet. This allowed for initial hunches to be recorded for later inspection and also for interpretations to be checked with participants.

In order to become immersed in and sensitised to the data, the researcher listened to the audio recordings of the interviews, transcribed them, and read and re-read the transcriptions a number of times before engaging in coding. Print-outs of the transcribed interviews were prepared with margin space for "manual" coding as recommended by (Saldaña, 2013). Memos were handwritten before being transcribed to Nvivo.

A short biography of each participant is provided below based on key attributes such as their place in the school or college process, school characteristics and CS experience. The four interviewees have been given pseudonyms and their school names are also anonymised:

Emma

At the time of the interview Emma was a 6th year student awaiting the results of her leaving certificate examinations and subsequent college offers[60]. Her school (School A) was an all-girls school until it was recently made co-educational, Emma completed her secondary school education in an all-female class environment. School A is a designated DEIS school in an area of social and educational disadvantage that has been involved with the Trinity Access Programme (TAP) for a number of years. Emma was invited to attended the CodePlus programme through the TAP link with the school.

All of Emma's CAO applications involve computer science and related courses her first choice being a degree in computer science at Trinity College Dublin. In addition to CodePlus, Emma was involved with a STEM outreach programme "The Walton Club" based in Trinity College Dublin from 2nd to 5th year. Emma also engaged in work experience in a technology company in her 4th (Transition Year) of school.

Ciara

Ciara had just completed her 2nd year of her Computer Science undergraduate degree in Trinity College Dublin. Ciara's first choice of college course was computer science; however, she did include choices related to the broader STEM area. Ciara is enjoying her course and happy in the college pathway she has taken.

Ciara's school (School B) is an all-girls secondary school, a designated DEIS that has also been involved in the TAP programme for a number of years. Ciara's school were one of the first in Ireland to offer computer science as a leaving certificate elective, however Ciara had left the school by the time the option was available. Ciara did not engage in any other STEM or CS outreach activities apart from CodePlus, however her school did offer a lunchtime computer club that she attended.

Victoria

Victoria had just completed her 3rd year of a Computer Science and Business degree in Trinity College Dublin. Her top college choices all involved computer science or computing but she also included some applications to courses that included sports and fitness. She is enjoying her course and summer internship.

Like Ciara, Victoria also attended School B and had left the school before computer science was offered as a leaving certificate elective. Despite attempts to find CS outreach activities in her area while in school, Victoria could not find any but she now volunteers at a CoderDojo for younger children. She did not attend the school computer club as she was committed to sports training the day that the club met.

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[60] At the time of submission, Emma has been accepted to study Computer Science at Trinity College Dublin

Ruth

Ruth had just completed her 3rd year of a Computer Science degree in University College Dublin. She is enjoying her course and summer internship. The course was her first preference and her other top CAO applications involved computer science followed by engineering and law.

Ruth attended a private all-girls school (School C). School C is not affiliated with the college access programme but as an all-female school was invited to participate in the CodePlus programme along with a number of other public and private schools. Despite her attempts to find other CS outreach activities she did not find any in her area. Ruth's school did provide a computer club that she attended for a number of years.

As previously stated, this group was an opportunistic or convenience sample, meaning the sample was chosen from those the researcher could access easily Cohen et al. (2013, p. 155). The author fully acknowledges that this affects the generalizability and representativeness of the findings, for example the participants may have been primarily motivated to give the interviews and consequent answers in order to help the author. Some strategies were taken to alleviate this bias, for example three different schools were represented in the sample, as were several different stages of educational progression in order to give a better representation than one school or year group alone. At the outset of the interviews each interviewee was encouraged to be as honest as possible and not to try and give answers to "fit" any agenda they thought the interviewer might have.

It is also prudent to consider the nature of qualitative research in which much emphasis is placed on the uniqueness of individuals in question that represent themselves and no one else, in this case the term "sample" can be misleading (Cohen et al., 2013, p. 161). Furthermore, there are no clear rules on sample size in qualitative research where size is informed by "fitness for purpose" (Cohen et al., 2013, p. 161). According to Onwuegbuzie and Leech (2007) the sample size should be large enough to generate "thick descriptions" and rich data, yet small enough to prevent data overload. In the context of this study, the sample of interviews of 30-45 minutes in duration gave sufficiently rich narratives that could be transcribed and analysed within the timeframe available. To that end, the interviews were not intended to offer definitive findings on the longitudinal impact of the programme for the general population sample, but rather serve as a means to explore key themes of the research through the deep perspectives of individual participants.

7.4.5.2.1 Holistic Coding

Each interview transcript was first coded using holistic coding strategies. The author made a deliberate decision not to apply codes uniformly across the transcripts as she was not yet trying to categorise and refine codes, but to explore each interview and its themes in turn. In keeping with this approach 80 codes were developed across the four interview transcripts. Many of the codes names were developed as in vivo codes, a strategy often used with other methods to remain close to the data (Saldaña, 2013). Later some significant overlap was found between the codes which the author re-arranged into refined codes and categories (See Table 60 below).

Categories	**Number of Holistic Codes Found**	**Refined Code Names/Number of codes**	
CodePlus Intervention	23	CodePlus as a Catalyst	6
		All female "safe-space"	5
		Constructivist learning style	4
		Exposure and experience	4
		Providing role models	2
		Improve Programme by making longer	2
Barriers faced	22	Lack of school opportunity	6
		Gender based bias and inequality	5
		Lack of peer and family support	5
		Lack of role models	3
		Lack of outside school opportunities	3
Positive Outside Factors	11	Peer and Family support	5
		Work Experience and Clubs	3
		Role Models	2
		Self-taught coding	1
Antecedent Conditions	9	Personal preference	5
		Early Interest	3
Outcomes	7	Contentment in course	4
		Set on CS	3
Observations	5	Observations	5
Metaphors	5	Bright clothing	2
		CodePlus as an "Eye opener"	3

Table 60: Holistic coding, refinement

By re-arranging the holistic codes into categories and "refined codes", the author was able to compare themes across the interview data set. A conceptual map of the this categorisation is presented in Figure 32 below:

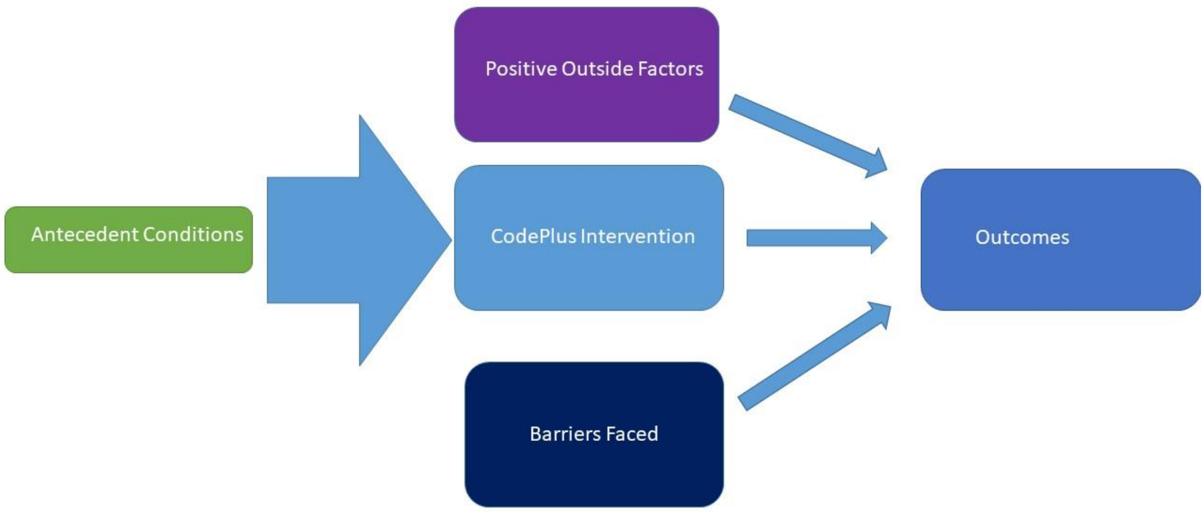

Figure 32: Concept map of holistic code categories

The conceptualisation of categories gives a general sense of the narrative structure and emergent themes of the interviews. The participants would typically describe some antecedent conditions such as an early interest in computers, gaming or STEM subjects in general. Interview questions concerning school and outside school experience with CS uncovered barriers such as a lack of access to activities and role models. There were a number of positive outside factors mentioned too such as family support, work experience and other outreach activities. The participants described their experience of the CodePlus programme and its

impact on their decision to study computer science. Outcomes involved the participants deciding to choose computer science and describing a sense of contentment in their course of choice. A number of more general observations on gender imbalance in the field were made by interviewees and noted. Several metaphors were noted from the holistic coding process including the CodePlus intervention described by 3 participants as an "eye opener" by three participants in their interviews, and two participants' using bright clothing as metaphor for standing out or being different as a woman in a male dominated CS college class.

The objective of the holistic coding was to begin to categorise the data in broad terms across the four interviews. The four narratives were similar and a number of themes emerged. Conceptualising the categories (Figure 32) also suggested the chronological and episodic nature of the participant narratives, although during the interviews these were not told in a strict order of occurrence, for example the interviews began with an "outcome" where the interviewee was prompted to discuss their current status as in school or college life. Throughout the interviews several key events or epiphanies (Denzin, 1989) were identified in each participant's narrative. The episodes and key moments were re-ordered in chronological sequence as presented in Figure 32 and suggested that a number of causes and effects could be derived from the data with further coding. The Causation Coding method would provide a more focused lens with which to investigate these causes and effects.

7.4.5.2.2 Causation Coding

It was observed during the holistic coding process that interviewees mentioned a number of specific causes and outcomes in their answers. By coding with the second chosen method, a total of 136 causal sequences were coded from the four interviews. Saldaña (2013) suggests that an extensive number of codes are necessary for causation coding analysis, as the author found in this corpus. Maxwell (2012) emphasizes that coding for causation should not fragment the data but instead examine the processual links embedded within extended excerpts.

Not all sequences included three-parts; antecedent variable(s) > mediating variable(s) > outcome, some consisted of an antecedent and outcome or a mediating variable and an outcome. In keeping with the approach of Saldaña (2013, p. 169), the 136 codes were organised into categories by outcomes. 12 general outcome categories were generated with the corresponding number of codes given in brackets:

POSITIVE CODEPLUS EXPERIENCE (19)

GENDER IMBALANCE IN CS (17)

DECIDING ON CS (16)

PERSONAL NEGATIVE EXPERIENCES (15)

LIMITED ACCESS TO COMPUTER SCIENCE (11)

THINGS CHANGING FOR BETTER IN CS (10)

CONFIDENCE (10)

ENCOURAGEMENT AND REASSURANCE TO STUDY CS (10)

OTHER CS EXPERIENCE (10)

ROLE MODELS AND CONNECTIONS (9)

MAPPING INTERESTS TO CS (5)

CONTENTMENT (4)

The following section will examine RQs 2 and 3 and sub-questions outlined in section 7.2, using examples from the causation coding analysis:

> Research Question 2: What are the longitudinal effects of the intervention?

Each research question was further expanded to guide the analysis. With regard to RQ2:

> RQ2(a): Was participation in the intervention a factor in deciding whether to apply for CS or related third level courses?

All four interviewees mentioned the role of the intervention as an influence in deciding to apply for CS or a related third level course. The two quotes below indicate a causal sequence in which the interviewees describe an antecedent condition ALWAYS KNEW/ALWAYS INTERESTED IN CS, an outcome SET ON CS and CODEPLUS "AFFIRMED" as a mediating variable:

ALWAYS KNEW + ALWAYS INTERESTED IN CS	>	CODEPLUS "AFFIRMED"	>	SET ON CS

RUTH: Really it was like after the CodePlus thing that I did, I was like, wow, this is great fun. Let me do this, because I do remember whenever anyone ever asks me, like, why are you doing computer science? I was like, well, back in fourth year I signed up for this course and I just had the best time. Yeah, it's really funny because, like, yeah, that's one of my favourite memories from fourth year. And then because I had such a good time with that, I like well I was always interested in computers beforehand, so it wasn't like a totally new concept to me. So when I went in and I like started learning about coding and stuff, I was like, wow, yeah, this is fun. I'll do this. Yeah, why not?

VICTORIA: When it comes to like deciding on the courses, I mean, I always knew I wanted to study tech and I think I throughout like even Bridge21[61] and things like that actually it kind of affirmed that's what I wanted to study**.**

In the quote below, Ciara puts a strong emphasis on the role of the intervention as an "EYE-OPENER". Ruth describes CodePlus similarly, and Emma also credits the programme as a unique opportunity to experience CS:

"WORLD I DIDN'T KNOW ABOUT"	>	CODEPLUS WAS "EYE-OPENER"	>	STUDYING CS

CIARA: Well it like opened up my eyes to like a world I didn't know about. That was like the main one. Like obviously I'm studying computer science now and it wouldn't have been if I didn't have..... like I honestly think if it wasn't for CodePlus I wouldn't be studying computer science right now. But, so like it opened up the opportunity of like a whole different world I didn't even know about sort of thing.

[61] Interviewees used the terms Bridge21 and CodePlus interchangeably at various stages throughout the interviews.

NO PREVIOUS EXPOSURE TO CS OR CODING	>	CODEPLUS WAS "EYE-OPENER"	>	MAPPING INTERESTS TO CS

RUTH: I'd say that it was good because I had not had any exposure to kind of coding or computer science before that course. So it was a big Eye-Opener to like, oh, this is something that I could potentially study in the future, you know, whereas beforehand, I mean, you wouldn't really be thinking about it in first second or third year anyway. But I hadn't really considered doing like something to do with computers in my future. So it was nice to kind of see that and be like, oh, well, that'll be fun because it was like it seemed to directly map onto computer science in my mind. I don't know why. I don't know if that was suggested by anyone. But in my head I was like, I like this course: Therefore I should do computer science, you know?

NO PREVIOUS EXPOSURE TO CS OR CODING	>	CODEPLUS	>	EXPERIENCING CS

EMMA: I think it was definitely through transition year and doing the likes of CodePlus that, because I was only talking about this at home, I don't know, like I probably never would have got to experience like coding or anything to do with computer science if it wasn't for the likes of CodePlus.

Another quote from Ciara below highlights the role of Codeplus as a springboard for joining the school coding club:

CODEPLUS EXPERIENCE	>	JOINING SCHOOL COMPUTER CLUB	>	PEER CS GROUPS

CIARA: I wouldn't have probably went to like Miss B's after school or lunchtime club sort of thing if I hadn't have gone to that week because I just, I didn't know what it was about so I wouldn't have went sort of thing you know that way? So that kind of just, it kind of just opened my eyes basically because I wouldn't have made the connection or I wouldn't have like initially went to Miss B's club by like, not like on my own accord sort of thing if it wasn't for the CodePlus week.

RQ2 (b): What other key factors contributed to deciding whether to apply for CS or related third level courses?

Interviewees were openly asked what factors influenced them in choosing to study CS, questions 4 and 5 on the interview protocol sheet asked the interviewees directly about on their school and outside school CS experience. A number of influencing factors were offered including relevant CS work experience, job security, peer support and prior interest.

Two quotes below suggest that Both Ruth and Victoria took job security into account when making a decision around choosing CS:

ALTERNATIVE SUBJECT INTERESTS	>	LESS SECURE JOB OPPORTUNITIES IN ALTERNATIVES	>	HELP IN DECIDING

RUTH: Well, it did seem rather more practical than the other big interests in my life, because the two big interests I'd probably have in my life are like computers, like computers and music. Right. So if I was to do music, I feel like that's a lot more not wishy washy, but a lot more difficult to do and like be successful or continuously successful and like have a reliable kind of, I don't know, income, probably not what that along the lines, I was thinking of like 17 or 18 or whatever, but it definitely plays a factor.

VICTORIA: I'd like to think I'd still do computer science because I wouldn't have known what else to do. To be honest, I wasn't really passionate in any other area, apart from computer science and health. But I was like, not a lot of money in there.

Ciara also mentioned her parents' approval at her choosing a CS course in relation to job opportunities:

CS JOB OPPORTUNITIES	>	PARENTAL APPROVAL	>	ENCOURAGEMENT

CIARA like I just kind of liked it and like my mom and dad like when I was kinda saying it to them they were like, yeah that would be a good job. Like it's going to be so many jobs available there. And they were like, it is going to be tough, but you'll be grand because, like, there's just so many opportunities there as well, you know, like there's so many opportunities for girls and there's so many opportunities just like, like there's so many new jobs that are going to be available sort of thing.

Both Emma and Ciara strongly credited their relevant CS work experience as key influence:

NEVER WANTING AN OFFICE JOB	>	WORK EXPERIENCE	>	REALISATION

EMMA: Yeah, because growing up I was always like, oh no, I'd never get an office job, like never it'd be so boring and I never could sit at a screen and just sit in a room for like that many hours in the day but I actually really enjoyed it. Like it didn't, it didn't drag in like the time kind of flew. So hopefully, hopefully it's still like that when I get a job.

	WORK EXPERIENCE[62]	>	REALISATION

CIARA: Then I did work experience as well in Google after that in TY and I just I was like, oh my God, this is amazing. Like, this is what I want to do.

Peer support was another key factor mentioned by Ciara and Emma:

WORRY ABOUT PURSUING CS	>	EXAMPLE OF “BRAVE” PEER	>	MAKING INTENT CLEAR

CIARA: I think I was like it was just like, everyone was like kept asking like what are you going to do? What are you going to do? What you're going to do? And I always kept trying to keep everything what I wanted to myself because in case I didn't get it. And then like, but I think one of the girls, like, she was like, she really wanted to, like she said, she really wanted to study medicine sort of thing. But in reality, she wanted to study like Irish and psychology. And with that she kind of came out and she was like, know what, like, I only want to do that because my

[62] No antecedent condition in this coding sequence (Saldaña, 2013).

mom and dad wanted me to do that, she was like, you know, this is what I actually want to study. And then we were all saying, like, what we actually want to study rather than what like are the stereotypical jobs people go for. It was kind of like around that time of like, you know what, I actually do want to study computer science sort of thing. So it's like one of my friends, she was brave enough, so I was like, you know what, me too.

FAMILY AND FRIENDS SAYING CS IS HARD	>	NETWORK	>	REASSURANCE

EMMA: (Talking about her colleagues from her summer job studying CS)

They really enjoy it, the older fellow who is in his third year? He kind of told me he's like, Emma, if I were you, I'd put Maynooth lower down seemingly compared to other colleges because he obviously knew friends doing it in other colleges. It was very like theory based as opposed to practical like projects and like labs and stuff. He said it was a lot of just kind of sitting and listening to theory as opposed to like doing stuff. So I think I still put down. But like I said, it's kind of lower on my list of colleges I do want to go to, but the girl she only done the leaving cert last year and she was in her first year, she was really enjoying it like I would because I was asking because every time I mentioned to someone that I wanted to do computer science, the first thing they say is, oh, that's a really hard course, like that's supposed to be really difficult. So when I met someone doing it, I was always like, so how hard is it like in maths or is it just like, for example maths in school, like what would be your average grade like just to try to gauge, would I be able for it? But listening to them I think I will be like well able, and I think I'll enjoy it as well.

All four interviewees spoke about their early interests in aspects of computing, note that Ciara has mentioned CodePlus as a mediating factor between this early interest and linking it to a future in CS and Victoria mentions a drop off in interest as she progressed through school:

INTEREST IN HOW THINGS WORK	>	MESSING WITH WEBSITES	>	PESONAL INTEREST IN CS

EMMA: Well I would have always kind of been like the likes of like new phones coming out and like computers and stuff. But like, I would have always had an interest of how things work more so than computers, if you know what I mean, like different like websites and stuff like that or like software programs or anything like that. I would have always like thought I wonder how that will work or do you know when you hit the button and then you can see the programming on the side of the website, like if that came up when I was younger I wouldn't have a clue what I was looking at it's just interesting kind of just how things work.

STRONG INTEREST AS A YOUNG CHILD	>	DROP OFF IN INTEREST AS GOT OLDER	>	POSSIBLY NOT CHOOSING CS

VICTORIA: So I guess when I was a young kid, I was probably five or six when I started playing around on the computer. And around that stage I was like, oh, I kind of like this. I mean, I liked to pretend I'd be a hacker one day. Definitely not where I'm going! Currently I'm working in a bank, but I always like playing games, that kind of exploring the computer, I was kind of the go to person in my family. So if something broke I would be be the one to fix it. But then going through primary school kind of forgot all about it, to be honest. And then in Secondary I went into an all girls school so Tech wasn't really a thing that a lot of girls talked about.

ENJOYMENT AND SKILL IN PUZZLES	>	CODEPLUS ACTIVITIES + REALISTATION CS IS “LIKE PUZZES”	>	MAPPING INTERESTS TO CS

CIARA: Like, I really like I really enjoy solving puzzles, like when we were going on holidays say in the airplanes and my sisters would always go get like magazines or whatever but I'd go get like the suduko books so I could do the little sudukos, doing the little puzzles going away. I always just really enjoy like puzzles, like kind of like that. And I feel like, computer science is a lot like puzzles. And like, when we did, when I did the CodePlus I kind of like discovered like what computing is and what computer science is. And it kind of just opened up like a whole new world kind of, so that was like the main factor I considered like going in like.

GAMING	>	INTEREST IN HOW THINGS WORK	>	PESONAL INTEREST IN CS

RUTH: Yeah, I was like, some of my first memories are like being dragged to the side of rugby matches and I didn't want to go to the rugby match, but my parents were mad into it. So I'd just bring my DS and I'd play like video games all the time. And then as I grew up, I was like, you know, you're on the Internet as a kid playing Club Penguin or just on YouTube. And then you know when Minecraft was released eons ago I was into that. And then it would be a bit of like, oh, how does this work? And then, you know, I don't know. It just seemed to always be a part of my life and stuff like playing like Call of Duty with my cousins and stuff. It was always kind of there and always quite fun.

All four interviewees described the limited CS opportunities that were available to them in and outside of school. Concerning CS outreach outside of school, just one interviewee (Emma) had attended any kind of relevant club. The organisation (The Walton Club) is a dedicated STEM club run by Trinity College Dublin for adolescents with an interest in the general field, including computer science. Both Victoria and Ruth mentioned that they tried to find or join such clubs:

LIMITED CS OUTREACH RESOURCES	>	CODERDOJO FULL	>	LIMITED OUTSIDE SCHOOL EXPERIENCE

RUTH: Yeah, there wasn't much. I must admit, I tried to join Coder Dojo, but like after the CodePlus. I was like, oh this is really interesting, I should continue with this. So I tried to join a local Coder Dojo, but they were already full so I couldn't do that.

"LIMITED CS OUTREACH RESOURCES	>	LIMITED OUTSIDE SCHOOL EXPERIENCE

VICTORIA: When I was younger, I think during the time while I was in Bridge21 when I heard about you, there was nothing local to me, at least not that I have found. So I was never part of any coding club, kind of Bridge21 was the only point of contact I had with someone kind of teaching us how to code.

The following quotes are illustrative of the limited exposure to CS the interviewees received in school:

TEACHERS NOT SKILLED	>	COMPUTER CLASSES NOT USED FOR PROGRAMMING	>	LIMITED SCHOOL EXPERIENCE

VICTORIA: Yeah, but the rest of the time I think they tried to push I.T. and computer science, but I don't think the teachers were skilled enough or were trained enough in it at the time I was still in school. I think they're probably a lot better now. Would it be a module? Oh yeah later on that computer science class just became, you know, free period to study during the leaving cert.

RUTH: I mean, there wasn't a lot of computers anyway, so it kind of just seemed like it wasn't like all the male teachers knew computers and all the females didn't because it wasn't like that just no one really knew about computers in a computer science sort of way, you know, like they'd know how to use one but...

FOCUS ON DIGITAL MEDIA	>	COMPUTER CLASSES NOT USED FOR PROGRAMMING	>	LIMITED SCHOOL EXPERIENCE

EMMA: From 1st year to 3rd year we done digital literacy, but sure that was just like PowerPoint and like Googleslides and stuff like that, like setting up your email address, like it wasn't, like that was the only connection to computers and the technology that we had. Like we didn't do any programming all really.

RUTH: I'd say it was pretty..... sparse, computer wise, you know. We, there, in my junior cycle, there was a computer, there was like a computer room where like you go and do languages, so you'd go sit the computer and do French for a bit. But there was never any like...Computer science bits, so it was really weird, my only kind of experience with computers would have been from just like personal interest stuff that I'd done at home.

It was interesting to note that despite outlining the shortcomings of their schools in providing CS exposure, Ruth, Victoria and Ciara all mentioned their school having lunchtime or after school computer clubs. Victoria did not attend as she had already had sports practice when the club met. Ruth did not elaborate on her experience of the club other than her “computer friends” she had made through attending and a peer had encouraged her to join. Ciara was initially hesitant to join the club as her peer group were not interested in joining but found the club helpful in provided a CS peer group:

SCHOOL FRIENDS WITH SHARED INTERESTS “COMPUTER FRIENDS”	>	JOINING SCHOOL COMPUTER CLUB	>	PEER CS GROUPS

RUTH: There was a girl in the year ahead of me and the girl the year below me that were like into computers as well. And the girl the year ahead of me, I remember we did debating together and we're actually quite good friends. But I think we met because we did debating together. And I saw she had like some Marvel pencil case. So we became friends and then she was like, Ruth , you're coming to this club. And then we'd also drag along the other child, the other student that was in the year below us. That was also our friend kind of into that like just like comic books, kind of like, you know, cringey emo music. You just go along and then we're also into computers. So we just kind of do that. It wasn't really there wasn't really like computers was the core part of our friendship. You know, it was just kind of more like, oh, I played Legend of Zelda when I was younger. And so there'd be this kind of mutual computers are pretty neat understanding you know?

CS STEREOTYPES	>	CODEPLUS + SCHOOL COMPUTER CLUB	>	REASSURANCE

CIARA: Like they kind of did like lessen my worries. I was like, you know what, I can see like other girls are doing it, and like girls were like interested in it as well sort of thing. And I knew like lots of the girls in school that were doing the afterschool club with Miss B and stuff like that, they were like really interested in it. But I'm like, I don't know, I was just still, like what if? you know that way? it was like kind of back of my mind, but like, I knew that like I wouldn't be the only girl, you know that way, but like I was just worried, like I'd be overshadowed, not overshadowed, but like oh, like. You know, I mean, kind of like overindulged maybe that would be the word, but yeah, they like lessened my worries kind of thing and they like they like opened my eyes to it, sort of like that it actually could be like an opportunity for me or it could be like a path for me to go down like if wasn't it wasn't for them. I wouldn't be studying computer science.

While Emma’s school did not have a computer club, Emma did mention several examples of teachers in her school actively supporting her interest in CS. Emma’s principal (Miss A) arranged for Emma to meet with computer science contacts in the college and another teacher organised work experience with a tech company.

TEACHER HAVING LIMITED INFORMATION	>	TEACHER LINKING WITH CS COLLEGE STUDENTS	>	MAKING CONNECTIONS

EMMA: Miss A was saying, I think I'm the first student in School A to be interested in computer science. So that's what Miss A didn't really know much about so, she put me in touch with a computer science lecturer and I had a Zoom call with him as well. And then he put me in touch with a, I can't remember her name, but an actual student who's in her second year of computer science in Trinity.

Similarly, Ciara mentioned that her school principal had encouraged her to apply for her current internship almost two years after she had graduated from her school. The author considers that in light of these episodes it would be unfair to dismiss the role of the school and teachers as positive influencing factors. While computer science was not offered as a formal subject, two of the three schools were offering extra-curricular computer science activities to students who wished to attend.

In summary, it was apparent all four interviewees had some prior interest in the nature of CS whether that was through gaming, puzzles or simply how computers work creating some antecedent conditions for an interest in the CS. Arguably, the interviewees had not necessarily made a connection between this interest and studying CS as Ruth, Ciara and Emma identified, and in Victoria’s case her interest had waned as she got older due to her school environment. Job opportunities and security was mentioned as an additional influencing factor, directly by two interviewees themselves and one interviewee’s parents.

Exposure to outside school CS activities were limited and although the author argues the four interviewees had access either to extra-curricular CS or teacher support, the accounts generally suggested that school CS experience was less than what they would have desired.

The following question will attempt to isolate the impact of the intervention for the interviewees against other factors.

> RQ(c): To what extent can the intervention’s longitudinal effect be meaningfully assessed against other factors?

As aforementioned in response to question a), both Ciara and Ruth were particularly strong in crediting CodePlus with their decision to study computer science. Victoria described the aspect of meeting a female CS student during the programme as a key moment in deciding to study computer science and returns to this event several times in the interview:

NO FEMALE ROLE MODELS	>	MEETING A FEMALE ROLE MODEL	>	ASSERTING ONESELF

VICTORIA: And then, I was in third year and I heard about Bridge21 from one of my friends who did it. And she was like, oh, you might like it. So when it came to TY and to applying to it, I was like, yes, I'm going to do it. And probably the point where I was definitely set was, I think, one of the first few weeks on the kind of code and coding week in Bridge21. I met a girl that was in Trinity studying computer science, and I think that was the point where I was like, OK, I can probably do it. It was just nice seeing a female, to be honest, because it was always males. And I guess from that point on, I was kind of like, yeah, that is what I want to do. And I well, I became it so.

(Later in interview... Victoria is asked about the significance of meeting the student)

VICTORIA: Definitely, to be honest, I don't even remember her name, I just remember asking her about coding and computer science and she was kind of just telling me about her story. And it was definetly kind of the first time I had a role model when it comes to computer science and tech, I don't know anyone. Well, before that time, I didn't know anyone who was a female and was in tech, none of my family knew anyone. And so it was kind of the first moment of finding kind of a role model in there and being like, I can be like her.

As Ciara and Ruth had given very definite assessments on the role of CodePlus, the question of the significance of the programme by comparison to other factors was asked later in the interviews:

GRACE: You said that you're very strong on CodePlus being a big factor in opening your eyes to computer science. And you said you don't think you'd be possibly doing it in college if you hadn't done the week. But I mean, you did have other influences I guess, like your school, you had the after school club, you had your own personal interests. You said that you enjoyed solving problems and puzzles and you were also interested in other STEM areas and all those kind of things. So just to push on that again, why would you say CodePlus was was so important by comparison to the other, if I if I hear you correctly in what you say, why was that so important to the other influences that you've mentioned already?

CODEPLUS EXPERIENCE	>	JOINING SCHOOL COMPUTER CLUB	>	PEER CS GROUPS + REALISATION

		+ CONNECTING		

CIARA: So I wouldn't have made the connection that like, liking puzzles and liking like crosswords, like whatever it is, like puzzles, or like sudokus or whatever. I wouldn't have made the connection that, like, I could do a job in computer science and that it's kind of like doing puzzles and lots of figuring out stuff and then, like, I wouldn't have probably went to like Miss B's after school or lunchtime club sort of thing if I hadn't have gone to that week because I just, I didn't know what it was about so I wouldn't have went sort of thing you know that way? So that kind of just, it kind of just opened my eyes basically because I wouldn't have made the connection or I wouldn't have like initially went to Miss B's club by like, not like on my own accord sort of thing if it wasn't for the CodePlus week.

GRACE: So would I be right in understanding it was like springboard for you?

CIARA: Yeah. That's what it was like, yeah. A hundred percent.

It is clear from the above exchange that Ciara is defending the role of the intervention as a key influence in the context of her other factors when pressed to consider. Similarly, Ruth was asked again about the main benefits of being a part of the programme:

GRACE: So you have actually touched on this a bit on this already. But I'm just gonna kind of ask you again, give you an opportunity to talk, what would you say for you were the main benefits being a part of the programme?

NO PREVIOUS EXPOSURE TO CS OR CODING	>	CODEPLUS WAS "EYE-OPENER"	>	MAPPING INTERESTS TO CS

RUTH: I'd say that it was good because I had not had any exposure to kind of coding or computer science before that course. So it was a big Eye-Opener to like, oh, this is something that I could potentially study in the future, you know, whereas beforehand, I mean, you wouldn't really be thinking about it in first second or third year anyway. But I hadn't really considered doing like something to do with computers in my future. So it was nice to kind of see that and be like, oh, well, that'll be fun because it was like it seemed to directly map onto computer science in my mind. I don't know why. I don't know if that was suggested by anyone. But in my head I was like, I like this course. Therefore I should do computer science, you know?

APREHENSION	>	CODEPLUS: TASTER	>	REASSURANCE

RUTH: Um, yeah, it was a great taster cause I enjoy being able to try something I have before I go for it for real, you know. So I definitely would have been a bit more apprehensive if I had never done any coding or like coding adjacent things beforehand. So it's nice to have a little reassurance that, OK, I kind of do enjoy this. I mean, it was just kind of fun. There was a nice atmosphere about it was fun. It was a little fun week where I got to make something with my friends. And then in town you feel like a grown up because you get to go down to spar and get like a coffee and a sandwich for lunchtime or whatever. You know, I have very fond memories of it.

Emma has also strongly credited CodePlus early in her interview as a key influencing factor. The following interview exchange highlights the role of CodePlus against other influencing factors:

GRACE: So just on CodePlus, Emma, what would you say were the main benefits for you taking part in that program?

LIMITED OPPORTUNITIES	>	PARTICIPATION IN CODEPLUS	>	UNIQUE OPPORTUNITY

EMMA:

I think just experience coding and even been introduced to it because like I said earlier, like, I definitely don't think like I would have heard about it but, and like maybe I would have like gone looking for courses, but I don't think I wouldn't have been as set on it, like I wouldn't have known as much about like I would never got to experience it. So even if I had it on my CAO, I would have been going into it like completely blind nearly because I wouldn't have any idea of what the work would actually be like and stuff like that and like what the course would like entail kind of. So I think for me that's the main thing, is just getting to see coding in the first place, because like I said in our school and stuff, it never really was brought forward to us, or like encouraged. Not that it was not encouraged either, but it just was never there. Like it was never really, when we talked about doing courses and stuff and people were saying what they wanted to do like it was just never mentioned.

GRACE: Look, I know it's really hard to to sort of, nothing exists in a vacuum, you know what I mean? If if I was to say you because, you did do your work experience, you did have your Walton Club, a couple of other bits and pieces. Was there anything that was different about CodePlus to those other influences? Because it sounds like it all contributed to your decision.

NO PEERS WITH CS INTEREST	>	CODEPLUS: PEERS WITH SAME INTEREST	>	ENCOURAGEMENT

EMMA: I definitely think that working with girls my age that had the same interest, because a lot of the again, the Walton Club even like the teams that I'd be part of up that like wanted to do anything with coding, I was nearly always the only girl that had, like an interest in it or something. It was like, I want to go on that team to work on that. Even in the work experience, like like I said, like I think when they had their meeting at the end of the week, like for all the company, like it was maybe 40 of them, only like maybe five or six were women. So I think it was just being surrounded by girls that had the same interests. And even like like you said, bring the women in. And it's like seeing other students just seeing that it is for women as well and I know that sounds so cheesy and cliche, like it actually really did encourage me as well because like I said, like even the girls, like I still have them on Instagram and stuff. And even then having the odd word with them and them being interested like in it as well. And so it was just nice to see kind of.

The segments presented above isolate the impact of the intervention against the multiple factors and influences affecting the interviewees decision to pursue pathways in computer science. Elements of the programme that contributed to this effect will now be explored with Regard to RQ 3: How did particular elements of the intervention's approach, design, and pedagogical considerations affect longitudinal change?

RQ3(a): How did the pedagogical design aspects of the intervention affect longitudinal outcomes?

The interviewees were directly asked what they remembered about their experience on the CodePlus programme and prompted to discuss the learning style where appropriate. The quotes below illustrate the self-directed, scaffolded learning style that was central to the pedagogical design of the programme:

EXPERIENCE OF INSTRUCTIONAL SCHOOL LEARNING	>	SCAFFOLDED + SELF DIRECTED LEARNING STYLE	>	FAVOURABLE LEARNING

EMMA: I definitely like I kind of like trying as much as I can to teach myself. And then when obviously, I can't all the time but like, I think it was just kind the comfort of having them there as support. But they weren't just trying to dictate it. Like it was like very like the learning I felt anyway was very led by, like me. So I kind of knew what I wanted to learn and even like within our team like whatever project we wanted to do. Like we were given a rough like, idea or something to go off. But it was never like, you have to do this or you have to do this. So it was a lot for us to decide on it. And I think then we'd try and try and try to get something right and it was only maybe when we'd try maybe four or five times, we'd say right can we come over. Like someone would come over and say, oh, you mean like, can I give you a hand with this? But even they wouldn't even just out straight tell you the answer they'd kind of just kind of push you in the right direction and try let you figure it out yourself as well, which I really enjoyed, because I think that's even, during transition year I think I really enjoyed like that type of learning because it's not learning you get often in school. So, I anyway, I think that's better suited to me.

CIARA: Yeah, I remember it was like completely different to school, So in school like, you'd be like you know like say if you're like in a class at school teacher would be like two plus two equals four and she'd kind of show you on the board sort of thing, whereas like obviously we got like a demo in CodePlus but then the majority of our learning was like go learn do it yourself sort of thing. So like we actually got like to play around with it and like learn like the different things, even like the card trick you didn't show us how to do it, we just go try do it, figure it out yourself sort of thing which I really enjoyed like kind of like exploring by yourself, like bringing it back to like the riddles and the puzzles like it was kind of like that.

	SCAFFOLDED + SELF DIRECTED LEARNING STYLE	>	“LIBERATED” LEARNING

VICTORIA: All I remember was being split into teams and then kind of us coming up with our own.... Well, I guess you had an agenda there with what projects you want us to do, whether they were filming a video or something else it was kind of liberating to know that we kind of could decide what exactly we would be working on and knowing that the Tuesday was always like an introduction day. It wasn't, it was kind of lighthearted. And then you had a project kind of for the next three days, which was nice, knowing you had a deadline, kind of you had to stand up and give a presentation at the end of the day.

RUTH: I just kind of remember sitting at a computer and just like we'd have, like I remember, you know, you'd do the brainstorming bit and we'd all come up with ideas and I'm rather loud so I'd just kind of yell out random ideas and probably something random and dumb would be the one we pick up. Right. So then we go to a computer and like, you actually have to try and figure it out. And I just remember every once in a while, like I'd do something and it would work and I'd be shocked and happy and they'll be it. And I'm like, I don't know specifically. I remember at one point one of the kind of mentors or tutors came over and they were like, oh yeah, to do this, you do that. And I went, ah but I tried that. And I preferred this way because X, Y and Z. And they were like, oh, good observation. And it felt very satisfying, to have like a problem. And I've seen it addressed it and kind of figured it out in my own head and. Yeah, well, serotonin, you know, when you figure out a problem that was quite nice and then yeah.

While the above examples are encouraging, it was found that discussing the pedagogical aspects of the programme at length was more challenging than anticipated during the interviews. This may have been due to the fact that the interviewees were being asked to recall events that took place anything from 2-5 years ago and understandably may not have been paying close attention to the pedagogical underpinnings of the programme's design! Nonetheless all four interviewees mentioned the scaffolded and self-directed learning style inherent to the intervention's pedagogical design and two described this as distinctive to school learning.

The following question will examine the other design aspects of the intervention and how they affected the interviewees.

RQ3(b): How did other design aspects of the intervention (all-female environment, college location etc.) affect longitudinal outcomes?

In addition to pedagogical design, the use of female mentors, an all-female environment and college location were design aspects of CodePlus. As aforementioned, Victoria was very clear on the significance of meeting a female student studying computer science mentoring during the programme:

NO PEERS OR FAMILY IN CS	>	CODEPLUS: VOLUNTEERS	>	FIRST ENCOUTER WITH A CS ROLE MODEL

VICTORIA: I know all the mentors were so nice, so, like, if you are stuck on something. You weren't scared about asking, but also knowing that the mentors were students allowed us to ask questions, which is nice, because if you were someone like me who didn't have a role model working in tech and you were interested in, either you came across someone that did kind of change your life at the end of the day. So it was really nice to have other students talk to you about their experience.

All four interviewees acknowledged the value of keeping CodePlus an an-female environment in order to provide a more encouraging environment. This view emerged from the data and which was also a direct question:

MORE INTIMIDATED IN MIXED ENVIRONMENT	>	CODEPLUS: ALL FEMALE	>	REASSURANCE

RUTH: I don't know, just as a child, I probably would be more intimidated if there was guys there and then I probably wouldn't have. I probably wouldn't have gotten into it as much as I did in back then, so, yeah, I don't know, it's weird. I can't tell if I would have liked it as much if there was mixed, but I think I appreciated that it was just kind of girls and just kind of people I knew already. Felt a bit safer, I suppose.

VICTORIA: think it was nice and I think it was needed for something just to involve the girls because. Oh, so I was kind of going back and saying, you know, I felt like there was a stereotype that only boys could do tech and study tech and they were all techie and we weren't allowed to do that. Not that I would feel uncomfortable being in that week but I probably wouldn't have asked as many questions knowing that there was a boy sitting beside me and he might not even have known the answer, but I would have felt like he knew more than me. And that's probably with females underselling themselves all the time. But no, I think it was it was nice that it was just for females because I think you guys see there was an issue and you tried to fix it and help in any way you could. And it was just nice working with females and, you know, making those connections. I didn't think of them as connections when I was in TY but I know that's what they were.

MIXED STEM CLUB	>	BOYS GIVEN MORE ATTENTION	>	FEELING INTIMIDATED

EMMA: I just think because often like just like thinking back to the Walton Club thing or stuff when I like I mean, Personally I think when you're, when I'm in a group and theres talking about, conversation, about coding or about like computer science the boys always take first.... they kind of... I , like their opinion, I feel is kind of nearly louder than ours and kind of valued more by whoever's listening, if you know what I mean? Like, I feel like it's just assumed that they know more what they're talking about because it is more male dominated. So it's kind of like they'll be, like people who believe what they say quicker, not that they won't believe us but like how much would she know about it or like does she even know what she's talking about like? So I think just having the comfort of, like it being all girls, you don't have that worry or I think you're more confident to stand up and gave your opinion or like that try new things and stuff. But you're not worried like people think I don't know what I'm on about like

GRACE: So you mentioned there, kind of like the, with all the other girls and the fact that you did go to an all female school, do you think the fact that it was all girls made any difference or would you have felt the same if it had been a mixed week when you came first?

BOYS IN GROUPS	>	TAKE OVER LEADERSHIP	>	GIRLS PUSHED ASIDE

CIARA: Oh, no. I think it would have been like worse it if it was mixed to me, because I feel like sometimes when you're in groups with boys, like I even find it in college now, like the boys would be like I'm a man and I know what I'm doing, like I'm going to be the leader. Whereas like when we're in our little groups, like, you could like, any of us could be the leader, like there wasn't a preconceived idea of who the leader was going to be. Because I feel like when you're like, if the boys had have been there, like the boys just would have been picked for leader automatically whereas like we had a chance to be like, you know, I actually want to be the leader you know that way?

The interviewees did not attach much significance the workshops being held on the college campus, however Ciara recalled seeing the freshmen students joining on her first week. Similarly, Ruth recalled the city centre location of the programme with fondness:

CIARA: I remember we got a week off school! We got a week off school and we went in like, we got to go to college. I was like, I think when I went to CodePlus it was like the first week in September so it was like my first week in college. I could see, like all the college freshers coming in to like freshers week sort of thing. And then we went to like this building the building was like all the green and it was like a real cool building, quirky or something

RUTH: There was a nice atmosphere about it was fun. It was a little fun week where I got to make something with my friends. And then in town you feel like a grown up because you get to go down to spar and get like a coffee and a sandwich for lunchtime or whatever. You know, I have very fond memories of it.

Emma recalled her trip to a tech company organised by the programme for a panel event. This event was identified with some significance as she was exposed to the "big building" and the work environment:

PRIOR MISCONCEPTIONS	>	CODEPLUS PANEL EVENT	>	REALISATION

EMMA: But I think to see that as well because I think it is such a, when you think of coding and computer science, you just automatically think of boys like. So I think it was definitely, actually just thinking back in transition year, as I actually done I think Salesforce it was a big company Salesforce, the company ran a like, a women in STEM kind of thing as well. So we went to that as well that had a panel I know is like two women, the software engineers for the company as well. I think, yeah, definitely. like, there was panels. there was women there. That was actually I remember, that was really interesting. I think as well even going into Salesforce and seeing the big building that even more so I was like, oh yeah, I'd love to work somewhere like that.

RQ3(c): Are there other factors emergent in the data that contribute to girls' predilections towards (or away from) career and college pathways in computer science?

Throughout the course of the interviews, interviewees described a number of distinctive barriers that they had faced in the course of deciding on following pathways in CS. This was not a question asked directly in the interviews but nonetheless several anecdotal episodes were offered by interviewees that were insightful. Near the end of each interview a question was put to the interviewees; "What do you feel are the reasons so few girls consider CS Pathways?" which was an opportunity for the interviewees to offer their perspective on the causes of gender imbalance and potential solutions.

Regarding the former, the key barriers that each interviewee described differed from each other. Victoria did not mention any barriers other than not having any CS contacts within her family and her CS not being discussed amongst her peers. These could arguably be considered passive conditions rather than barriers or inhibitors. During her interview Emma mentioned two incidents in which people around her led her to question her ability to be accepted to CS undergraduate course, one of whom was her father:

FAMILY AND FRIENDS SAYING CS IS HARD	>	NETWORK	>	REASSURANCE

EMMA: (Talking about asking her summer job colleagues about studying CS)

I was asking because every time I mentioned to someone that I wanted to do computer science, the first thing they say is, oh, that's a really hard course, like that's supposed to be really difficult. So when I met someone doing it, I was always like, so how hard is it like in maths or is it just like, for example maths in school, like what would be your average grade like just to try to gauge, would I be able for it? But listening to them I think I will be like well able, and I think I'll enjoy it as well.

GRACE: Yeah, that's really interesting that people would say, oh, that sounds really difficult, or that sounds very mathsy and?

EMMA: Like they're always like, oh, hope you're good at maths or like anyone I say it to like even when I first said it to my Mam and Dad like even my Dad at one point was like that's really high points Emma. Like without trying to tell me I wasn't able he was like, do you think it's achievable? Like, I don't want you being, have your heart set on something and then not getting it. And I was like, no, I was like hopefully I'll get it as long as they don't go up any higher but.

This interview segment is a classic example of the commonly held view that CS is inherently more difficult and maths based by comparison to other subject areas. Undoubtedly Emma's father is managing his daughter's expectations with her best interests at heart but Emma does appear to recognise that her ability is being gently questioned. In the first segment, Emma responds to these worries by asking peers studying CS about their courses. This episode highlights the importance of students linking with CS role models and peers when there are none available to them though their family networks for support and guidance.

Of the four interviews, Ciara’s was the only story in which an interviewee described how she had worried considerably about choosing CS for college despite having a strong interest and desire to pursue this pathway. There were two key reasons Ciara identified for this; Ciara had no family connections to the field and secondly, her peers’ stereotypical perceptions of CS influenced her own self-perception:

HAVING NO ONE IN FAMILY WITH EXPERIENCE	>	CS AN UNFAMILIAR FIELD	>	FEELING INTIMIDATED

CIARA: I'd only known what I found out from school and doing activities about computer science. So I wasn't really sure, like what else was there? Because, like, I don't have anyone at home, just like my mom and dad. They don't work in the STEM field or like none of my aunties and uncles kind of do either, like we've no family friends that like study computer science. So then I was kind of like, that aspect kind of scared me a bit. So that's why I was kind of like, oh, like, will I do it? won't I?

GRACE: That's great, yeah. And I guess Ciara then when you know, we were talking there about when you started to make up your mind in sixth year, that was what you were, you were going to do. Would you say there was a point where you really made up your mind that that was something you were you were going to do and was that before filling out the CAO form?

ENDURING STEREOTYPES	>	OPINION OF PEERS	>	WORRY

CIARA: I'm actually not too sure. I think I just like I always I was always in the back of my head. And I think it was just kind of like the turning point like, I kind of just like was like, you know what, like I don't really care what anyone thinks anymore because a lot of my life was like, oh, will I go into it when it was kind of like all my friends will think, I'm like a nerd and or like, oh, I'm going to be the only girl in the course sort of thing. And I kind of just like. I'm just like, you know, like it's actually something I want to do so like, I'm gonna say like F it like sort of thing you know that way? I don't really care what anyone else thinks so like I'll just do what I want to do like I don't care like if the girls think I'm a weirdo doing it because like that's like the stereotypical thing you think of going into computer science like my first day I was going in, I thought everyone was going to be like super weird and like super like in the movies, but like it ended up not being so thank God. I didn't think I fit the stereotype of going to it, but then I was like, well, I don't care, I'll just do it anyway, and that's kind of my deciding point.

CIARA: (Talking about the causes of the gender gap in CS) And then another thing is like your mates and stuff like that, because like as I said, like my mates are like, oh, it's a bit of a nerdy subject. They were like. You're going to be one of them people hood up in the back of class just on your computer all the time. We're never going to see you again. You'll be in a room the whole time sort of thing. So I feel like, you're kind of like scared that you'll fall into this stereotype or like that everyone in there will be the stereotypical computer science student who like doesn't talk to anyone. And you're like, I'm not going to have any mates when I go to college sort of thing. But obviously that's all, that's just a stereotype, like, OK, that's like a big thing like people are like scared of the people that will be in there, even though like people are normal in there.

It is apparent that Ciara was in conflict for a time with her desire to pursue CS and the opinion of her peers. Earlier in this section, a segment was shared in which Ciara described the turning point of sharing her intention to apply for CS with her peers following the example of a friend who was "brave enough" to go after the course she wanted. Ciara also credited both CodePlus and subsequently joining the school computer club with giving her valuable peer support. Section 2.5.4 of the literature review discussed the influence of adolescent peer-support in relation to the wider area of STEM careers; When friendship groups do not support STEM and are primarily female, girls may find it more difficult to view STEM as compatible with their social gender identity (Robnett & Leaper, 2013). Regarding CS, peer-pressure for girls to conform to gender-norms may affect motivation to pursue the subject (Cohoon & Aspray, 2006), while Master et al. (2016) proposed girls may avoid computer science as prevailing stereotypes signal to them that they do not belong. Ciara's account is an example of these external agents of socialism having an influence and highlights the importance of peer-support as an encouraging factor.

The key challenge that Ruth spoke about was the hostile behaviour she had encountered from boys when playing online games in adolescence. Ruth recalled this behaviour when asked about the significance of keeping CodePlus an all-female space. In the following interview segment, the author returned to the incident:

GRACE: You just mentioned there of being in... sorry was it a Call of Duty club?

GAMING LOBBIES	>	BOYS HECKLING	>	FEELING INTIMIDATED

RUTH: Yeah. It's just like the little, the little kind of online, well it's a joke but it's kind of real life too right where you'd like join a game lobby and you know, like girl has microphone on and says anything and then everyone's like is that a girl girl? And then you get heckled a bit and you're like maybe I shouldn't. And it's like, that's not it's not fun, first of all. And it also is kind of deterring. Right. Because, like, I definitely you know, as you get older, you're like, maybe I don't want to be heckled in my free time. So you either turn off your microphone or you just kind of stop. Right. Which is unfortunate because I think it, I know it's like Call of Duty game lobby, which is like very odd, but I think there's like an import, there is a strong connection between like being into like the Internet and gaming and stuff and like wanting to do something like engineering or like kind of software engineering, like. So I feel like if you get discouraged from the one, it's not I don't know how like, how likely you are to be discouraged from the other, but in my mind, it's quite a strong link, right? So I'm just like in my head. I might have also carried that over into the week where if there was guys there, I might have been like, oh, maybe I should just, like, log out of this mentally a bit and just take a back seat, which is unfortunate, but I feel like I I wouldn't have done that now because I'm quite loud and outspoken now. To be honest, I definitely try to go against that, like, you know, like in college. I try to put myself forward for a lot of things because, you know, there's the thing where I'm like, oh, maybe I shouldn't. I'm like, why shouldn't I? You know just go for it anywho? Like applying for that internship I was like why should I? But you know just go for it anyway, but back then, you're younger, you're like shyer, I guess in my case that definitely, anywho so I don't know, might have been more discouraged. Might have not enjoyed the week as much because I didn't participate, might have not done computer science. You know, there's a lot of might of's in that sentence, but I don't know, I could see it potentially happening.

Ruth also added that she makes efforts not to reveal her gender during gaming sessions to avoid this behaviour:

RUTH: You know, like it's why you like if you're playing like some online game, I choose something that doesn't appear feminine, you know, as opposed to something that would have, like, my name or like something else in it.

Ruth also gave several examples of experiencing misogynist behaviour from her male classmates:

GRACE: And have you ever, it sounds like that memory, like when you were 14 is pretty strong for you. You know, that that incident getting heckled. Is it ever something that you came up against in college?

BOYS IN COLLEGE	>	SEXISM	>	FEELING ANNOYED

RUTH: I mean, and like in same dumb way of, like, people trying to make jokes? Yeah. Like, it's really, it kind of annoys me a little bit. But like, you know, in first year, like, they'd be like, oh, we need like ten people up here to, like, do a little example, like a sorta like a sorting algorithm or something. And I was in first year and I was like, OK, I'll do it like for first year college. And then like you go up, you stand there and then they're like, OK, you're all like engineers or someone. And then someone in the back of the hallway like, oh, girls shouldn't be blah blah blah. I didn't exactly hear them, but I heard the words "girls shouldn't be" And I was like, oh, Jesus Christ, you know? And then.... I don't know, there's jokes like, not to toot my own horn, but I get kind of good grades, Right. And there have been one or two jokes where it's like, oh, Ruth's only getting good grades because she's the girl bias. And I'm like, ha ha ha. You know, I'm just like, shut up. But, you know it happens.

It's clear that Ruth recognises these incidents as examples of male hostility towards her and how this behaviour damages confidence. In the first segment, Ruth mentions that a mixed gender CodePlus environment may have led her to "take a back seat" due to experiencing hostility from boys in the gaming environment. These episodes of misogyny that Ruth shares are examples of behaviour that is well documented in the literature on the CS gender gap (A. Fisher & Margolis, 2002; Hewlett et al., 2008; Klawe, 2013).

Interestingly, both Ruth and Ciara shared incredibly similar stories on their first day enrolling in their CS undergraduate courses. Both women elected to wear "bright" clothing and spoke about standing out from the other students.

ANXIETY STARTING COLLEGE	>	BRIGHT CLOTHING METAPHOR + BEING BRAVE	>	ASSERTING ONESELF

RUTH: Oh, my God, there's this crazy photo actually in first year of college, which someone, one of my friends sent into our group chat in first year. And it was of one of the first like lectures we went to, the lecturer decided to take a photo. And you can see like there's a lot of guys, definitely. But I was really stupid that day I guess and I decided to wear a <u>bright orange jumper.</u> And it's just a really funny photo because there's like everyone in the room, they're all guys, and then there's me in a bright orange jumper and there's like no one either side of me, like three ways. It's really wild. Like there I am.

CIARA: Because it's. kind of, when I went to college on the first day and I was like so nervous and I was like I walked in and I walked in with a <u>big bright pink jacket</u> on like on the first day. So everyone saw me walking in, but like they kind of just sat beside me and like, I'm like a big mouth now, obviously, as you know. So I'd be talking like ah what's the craic how are you to the person on the left and then like, I'd kind of just get to know people and like, obviously there's a few people like you don't, you're not friends with everyone. You're never gonna to be friends with everyone. But like there's so many people on the course that you will be friends with. So like it's so easy to make friends there because everyone's there for the same reason everyone is thinking the same, like, oh, like, I'm so scared like I'm not going to make friends, but everyone's the same like you know that way? Like, I'm sure it's the same in all courses it's just because computer science is like the stereotypical one but I'm sure is the same in all courses, everyone's scared to make friends on the first day...

It is interesting to consider the bright orange jumper and bright pink jacket as metaphors for both young women expressing their identities and asserting themselves in the CS undergraduate environment. In Ruth's case her outfit makes her stand out in the male dominated class. It should be noted that in text the tone of humour in which Ruth told the anecdote is not fully captured, and Ruth also presented a copy of the photograph she had kept on her phone. It can be considered that Ruth intended this story to be understood as a significant albeit amusing example of standing out in the male dominated class. Ruth mentions the episode again when talking about the gender balance improving:

RUTH: And it's like, well, it's great that we're getting more balanced because, like, it's it's weird when you look at your photo in first year and you're like the one girl in the centre of the room and then everyone else is like five seats away. But then I'm in this internship and there's like half and half girls and guys on my team and that's like nice. You know, it's great to see, I think, anywho...

In Ciara's story she seems to have taken a leap into making friends and asserting herself following her unintentionally eye-catching entrance to the class having felt nervous and scared to make friends in a course clouded in stereotypes. It is interested to consider how Ruth and Ciara had both faced challenges concerned with their own identity and entering college CS. The anecdotes were told near the end of both interviews and gave a sense of closure and resolution for the interviewees.

To conclude the interviews, all interviewees were asked an open question to share what they felt were the reasons so few girls consider CS Pathways? Collectively, the reasons offered were; societal norms, historical cultural and gender roles, enduring stereotypes, the gendering of secondary school subjects, a lack of resources, and a lack of role models.

Victoria offed a view that the enduring stereotype as CS as a male profession affects girls coupled with a lack of female role models and access to CS contacts. Victoria offered that bringing in CS for schools would help "bridge the gap":

ENDURING STEREOTYPES + LACK OF ROLE MODELS + NO CS NETWORK	>	GENDER IMBALANCE

VICTORIA: I feel like I'm repeating myself, they're projecting the stereotypes that it's always males in the movies coding. It's very rarely that you see a female doing the coding in a movie and you know, moving on to your role models. There isn't that many maybe for them, but, you know maybe there are the role models but it could be families like mine who don't have those connections and that network. So bringing in computer science as a subject has, like is going to definitely help bridge the gap.

Victoria went on to suggest that women experience bias in undergraduate CS courses, with an interesting view that males feel “attacked” due to stereotypes:

STEREOTYPES	>	“MEN FEEL ATTACKED”	>	MALE HOSTILITY TOWARDS WOMEN IN CS

VICTORIA: But then even when you go on to be a student in college you still kind of feel that bias towards you if you're a female, and I don't think it's on purpose, but I think, because there have been so many stereotypes and the males feel like they've always been attacked, you kind of feel that way. But I'm hoping that, with more people encouraging females to code and go into tech, this will kind of slowly make its way out. And you won't really feel that bias anymore.

Emma and Ciara offered very similar views on girls’ schools placing as much emphasis on CS as other subjects:

SOCIETAL NORMS	>	BOYS PUSHED MORE TOWARDS CS + GIRLS PUSHED TOWARDS OTHER SUBJECTS	>	LESS “PUSH” ON GIRLS TO STUDY CS

EMMA: I feel girls just aren't encouraged in it, like in a school, like it's just never mentioned. And I don't think the schools do that on purpose. I think it's just the way we're just like programmed is just these are the boys subjects, these are the girls subjects.

CIARA: Yeah, like even like in schools, like, you know, we are just talking to teachers about like what you want to study, like or whatever. Like I feel like there was never anyone being like computer science, well, there wasn't never anyone like, but there wouldn't be as much of like computer science as an option as there would like, nursing is an option or teaching is an option

BOYS GIVEN MORE INFO ON CS	>	GIRLS LACK OF INTEREST IN CS

CIARA: I feel like a lot of young girls as well, they don't know much about computer science because like my little sister is in third year now, and she is like, I don't know what to do. And I'm like, well, computer science is always an option, she's always asking me questions like, oh, what's it like? What's this? What's that? So I feel like if there's some more information about it, and I feel like the information, if there is information out about it, it's more like kind of like shown to the boys, rather than to the girls sort of thing so the gender gap would be another like a big thing.

Ruth gave the most lengthly answer to the question of the four interviewees, several key points are offered below:

HISTORICAL CULTURAL AND GENDER ROLES	>	GENDER GAP

RUTH: Well, I think I like I like to think of these questions because they seem rather big and rather intimidating. Right. Why is there a gender gap in computer science? That's a question that I think goes back really, really far to like all the gender stereotypes of way back when and also kind of today. But the things that are more evident way back when, you know, we're like a woman stays home and looks after the kids and the guy goes out and does work and stuff. Right.

GRACE:If I understand, you said you don't buy the argument that, just pejoratively, Oh, girls just aren't as interested in computer science, which is something that you hear constantly. And then you said, well, I think there's a why. There's always a why.

RUTH: Yeah, there is always. Yeah, exactly. So, yeah, it's not that girls aren't interested because we have counter examples and it's about letting kids just kind of like decide, like kids just in general like if you say like girls and boys, then it's like, well you're already making the distinction there that I feel like doesn't need to be made when it comes to like what you're doing. Right. The problem is that this distinction was made for so long and it was affecting one group negatively for so long that you need to do something to counterbalance that.

RUTH: I don't know. It's what I don't buy the whole... I don't buy the whole girls aren't interested in X or guys aren't interested in X, because I think we're all we're all influenced by the society that we live in that says what people should like. Right. Which isn't good in general, but because we're part of that society. It does affect people. And there are ways you can make the statements saying that, like, guys are usually more interested in football. And I'm like, OK, but you shouldn't let that determine who you allow play football if you get me right. So if you're only allowing guys or you're pressuring guys to do computer science, well, then what about the girls that want to do it right? So I say it's not about like it's not about getting more girls to do computer science, it's about showing them that they can if they want to, you know, which was kind of like the course, right?

In the examples shown, Ruth is very aware of the societal and cultural context of gender imbalance. Like Emma and Ciara she believes that boys are given more push towards the subject than girls and refutes the view that “girls just aren’t as interested”, believing the problem to be more nuanced.

7.4.6 Summary of Interview Analysis

The analysis of the interview data presented above suggests that participation in the CodePlus programme was a significant factor in choosing CS college courses from the perspective of the interviewees. The impact of participation in the programme can be inferred in the context of other positive contributory factors and the limited exposure to CS resources that the interviewees described. The following subsections summarise these elements in turn.

7.4.6.1 The “CodePlus Effect”

Both Ciara and Ruth described the course as an “eye opener” that exposed them to coding and CS, and both interviewees along with Emma also credited CodePlus as one of the main reason they had elected to study CS in their own words. Victoria cited the specific aspect of meeting a female CS student during the workshop as a key motivating moment in deciding to study CS. These individual testimonies strongly point to a “CodePlus effect” for each interviewee. It should be noted that all four interviewees were challenged by the interviewer on this assertion with follow up questions on other influences and predispositions that could have had a similar or greater impact (to avoid accepting such positive claims without allowing for further reflection). Nonetheless the interviewees remained firm on the key influence of CodePlus in their pathway to CS.

Certainly, all four interviewees described some antecedent conditions to their participation in the intervention. Ciara's love of puzzles, Ruth's gaming, and Victoria and Emma's general interest in how computers work were all early precedents described during the interviews. It was interesting that both Ruth and Ciara acknowledged they had not connected these interests with studying computer science until they attended the programme. While the argument offered that girls are simply "less interested" in computers endures in some domains, the interviews were a good medium to tease out early preferences that infer an aptitude for computing. It would be interesting to explore the question of early interests with a larger sample to look for patterns in the preferences of those who go on to study CS and those who do not, or perhaps the majority of young girls enjoy such activities and don't make the connection? The intervention was designed with activities that presented computing in the context of problem solving, media, gaming and other real-life applications, to make explicit the relevance and ubiquitous presence of computing to participants .Particular aspects of the intervention design will be discussed in subsection 7.4.6.3.

7.4.6.2 Context: Limited Exposure and Resources

All four interviewees were critical of the limited CS school resources available to them. None had the option of taking CS as a leaving certificate subject and computer classes leaned towards digital literacy rather than coding based on the accounts given. Ruth, Victoria, and Ciara did however mention that their schools offered computer clubs; Victoria did not attend the club due to other extra-curricular commitments, Ruth attended but did not place any great emphasis on her involvement in the club other than making "computer friends", Ciara was highly reluctant to join hers as her peers were not interested in joining. Ciara did eventually join the club following her participation in the CodePlus programme and does credit the club with encouraging her interest in pursuing CS as a college pathway and providing peer support. There was also some strong evidence of teachers giving substantial support to the interviewees in encouraging their interests, in particular Emma mentioned two teachers linking her with work experience and college contacts. For this reason, the general narrative of limited CS exposure in school that emerged from the interviews should be viewed with some healthy scepticism! It would be an interesting avenue for further study to examine the role of schools in providing supports and exposure outside of the formal curriculum such as those described above.

The interviews painted a picture of limited access to CS outside of school. Ruth and Victoria both made efforts to find activities following participation in CodePlus and were unsuccessful. Ciara mentioned that she would have but didn't know where to find any such clubs or activities. Emma was the only interviewee of the group that had some exposure to organised CS activities outside of CodePlus through her involvement with the STEM club. Emma mentioned that she used the club as a resource to further her interests in CS whenever given the opportunity. These accounts tallied with the results of the longitudinal survey data which painted a sparse landscape of CS opportunities available to participants which could be further explored in future research. Access and opportunity to experience CS inside and outside the formal school curriculum is a key challenge in addressing the gender digital divide as discussed in the literature (Section 2.3.4).

According to their own admissions, it is hard to dispute that all four interviewees initially had limited access to CS role models, male or female. The relevance of this issue was particularly prominent for Ciara, who worried considerably about entering a field without any contacts to fall back on. Similarly, Victoria mentioned not having anyone in her family network and how meeting a female student through CodePlus was important to her in this regard. Emma spoke about taking the initiative of speaking to whoever she could about studying CS; her teachers, CodePlus contacts, Walton Club mentors, work experience colleagues, students from her summer job. One could consider this as an example of a highly motivated young woman who was hungry for information and support not readily available to her. Again, these admissions correlated with the findings of the survey where there was a considerable difference between the number of respondents that indicated having at least one male role model compared to having at least one female along with a greater number of male role models across all comparable categories (teachers, relatives, friends etc.). These interview segments gave a deeper insight into to clear benefits of programmes providing female role models for impressionable young women, and goes so far in the case of Victoria as being a lightbulb or catalyst moment in her personal pathway towards CS.

Finally, all four interviewees made reference to the role of peers as an influencing factor. Ruth had a peer group of "computer friends" formed in school who shared her interest, although she did mention that these were not classmates from her year. The other three interviewees mentioned being somewhat different or unique to their peers in their interest of CS. Victoria mentioned CS as "something not really talked about" by her friends, Emma shared her principal's observation that she would be the first student in School A to apply for a degree in computer science. Arguably a perceived lack of peer support affected Ciara the most, and led her to be conflicted regarding her decision to pursue CS. All four interviewees did go on to acknowledge the value of CodePlus in allowing them to meet other girls with a "collective interest" in CS. The influence of peers as external agents of socialisation in regard to girls' predilections towards CS was discussed in Section 2.5.4, and would be an interesting avenue of further research in this context through interviews, given the complexities of peer relationships in adolescence.

7.4.6.3 Design Elements of CodePlus contributing to impact

The interviewees did not offer a detailed analysis of the programme's theoretical underpinnings. When asked what they had remembered about the programme, the interviewees did make reference to the team-based, scaffolded nature of the learning as being favourable to them and distinct from the typically instructional nature of much formal school learning. This corresponds to the findings of the short-term qualitative data (Section 6.4.2), where it is understandable that the participants did not offer an academic critique of the learning model but rather acknowledged aspects of the methodology in their own words and experience.

The programme location was also favourably referenced by several interviewees who noted the campus afforded them an encouraging glimpse of college life. The longitudinal survey data also reported that over 70% of respondents rated spending time on the college campus a valuable or very valuable aspect of the programme in terms of helping decide whether or not they would be interested in studying CS. Emma recalled a visit organised by the programme to large tech company where she met a panel of female developers and engineers as a highly encouraging episode. Such events and initiatives have already been adapted by a number of outreach programmes (Chapter 3). For CodePlus and similar initiatives to branch out into facilitating company visits and partnerships with professional women, a powerful impact could be made.

The design element of CodePlus as an all-female environment did prompt more extensive responses with some insightful perspectives on how the inclusion of boys tends to affect the levels of participation among girls. There was some consensus that girls may tend to take a step back in the presence of boys, whether this was purely intrinsic or in response to the active efforts of boys wasn't entirely clear. Ciara offered that girls are less likely to lead in the presence of boys in such situations as the social norms of the group would dictate a boy should lead. Emma offered a view based on her experience at the Walton Club that girls are less likely to speak up in the company of boys when discussing CS due to instructors giving the "louder" boys more attention. Similarly, Victoria also offered that she possibly would not have asked as many questions during the programme if she had been sitting with boys, feeling that they would be inherently more knowledgeable about the subject than she. Ruth in recalling an incident of male hostility towards her in a gaming lobby suggested that this experience may have led her to take more of a back seat at CodePlus had the environment been mixed. Some of the language used to describe the all-female environment; "safer", "a comfort", was telling in providing a perspective on girls' experience in relation to gender and learning environments. These testimonies while troubling are also enduring from a narrative perspective and go back to the observations of Margolis and Fisher (2002) and Spertus (1991) on the gender-culture in computer science environments. It is beyond the scope of this study to examine this barrier to young women in further detail, but it certainly flags misogyny and sexism as challenges to be addressed for further research.

7.4.6.4 Other Factors Contributing the Gender Imbalance and Things Improving

All four interviewees proposed reasons as to why so few girls consider CS pathways. Collectively, the reasons offered were; societal norms, historical cultural and gender roles, enduring stereotypes, the gendering of secondary school subjects, a lack of resources, and a lack of role models. Certainly, the interviewees recognised the issue as complex and multifaceted, in particular Ruth, who offered a lengthy perspective on the societal and cultural norms that contribute to underrepresentation. Discussions like these could form the basis of an action research project for future work with a larger sample size, as in Ruth's case she demonstrated a very clear understanding of the key issues and many of the themes that emerge from the theoretical and empirical data on the central phenomenon under investigation.

Equally, the solutions offered were to provide more exposure to girls in the form of introducing the subject option in schools and for more outreach programmes such as CodePlus. It was suggested that tech companies and other stakeholders had a role to play to in supporting initiatives and actively taking measures to encourage female participation. These suggestions give further support to the author's recommendation that tech companies and female role models should work in partnership with outreach initiatives.

It is important to add that both Victoria and Ruth offered a view that they sensed things changing for the better for women in CS through observations they had both made in their internships and CS volunteering opportunities. These offerings combined with the fulfilment the three college students (Ruth, Ciara, and Victoria) expressed in the path they had taken was a positive note on which to close the analysis of the interview data. In time, Emma would hopefully follow in their footsteps and realise her ambition of attending University to study computer science.

7.5 Chapter Summary

The analysis of the longitudinal stage of study suggests that the intervention was a key influence for a number of participants in electing to study a CS or related course. This was inferred both from data that directly investigated the effect of the intervention and contextual data that highlighted the limited external CS resources and supports available to participants. The survey data provided a general picture of this landscape in quantitative terms whilst the interview data provided individual rich narrative accounts in which the impact of the intervention and other factors were explored in context of each interviewee's pathway to CS.

The quantitative survey results suggested that both the programme workshops and career talks aided participants in making an informed decision as to whether or not they would be interested in pursuing a CS related third level course, and attending advanced CS workshops with the Bridge21 and CodePlus programmes were significantly associated with applying for CS related third level courses.

The interview data supported many of the quantitative data findings, in particular the limited CS resources available to participants, and offered deep perspectives on the impact of the programme in the context of other multifaceted factors and influences. The importance that the four interviewees placed on their participation in the intervention was made clear, and many other insights were given on the nature of what positively and negatively can affect decisions to study CS.

There were several key limitations acknowledged in relation to the survey and interview data collected. Both samples were opportunistic, therefore the generalisability and representativeness of the findings should be approached with caution. In particular, the author acknowledges how her relationship of trust with the four interviewees may have played a role in the suggestion from all four that the CodePlus programme had strong significant impact on their decision to study CS. By contrast, one could argue that this relationship was as much a strength as it was weakness of the interview data. As Woods (1986) write, “There would have to be a relationship between the interviewer and interviewee that transcended the research, that promoted a bond of friendship, a feeling of togetherness and joint pursuit of a common mission rising above personal egos”. In short, the author believes that her relationship to the interviewees and indeed her own gender contributed to meaningful and truthful testimonies from the participants.

The attrition rate from the short-term to the longitudinal survey was considerable, an occupational hazard of longitudinal studies that was further exacerbated by school closures during the data collection period. This sample size would not accommodate the same power of statistical testing the short-term data could, however the sample was still well above the minimum size of 30 cases commonly recommended for statistical analysis in educational research at 75 participants (Cohen et al., 2013, p. 144) and much of the contextual data gathered gave greater insight into the landscape of resources available to the cohort. The instrument itself is a tool that future studies may adapt and utilise with larger samples to establish enduring effects of CS outreach programmes on CS college pathway decisions.

8 Discussion and Conclusions

8.1 Introduction

Gender-imbalance in the field of computing is a recognised inhibitor to women’s rights in the 21st century and the realisation of an equitable and just information society (Nations, 2015). On the rapidly accelerated pace of technological development Schwab (2017, p. 1) writes:

“We are at the beginning of a revolution that is fundamentally changing the way we live, work and relate to one another. In its scale, scope and complexity, what I consider to be the fourth industrial revolution is unlike anything humankind has experienced before.”

The “gender-digital divide” risks a future society where women do not have an equal stake in a connected and digital world, to the detriment of female empowerment and emancipation, hard-fought for by our foremothers. The cause of women’s rights and equal citizenship is a core value of this dissertation that aimed to educate and encourage adolescent girls to explore pathways in computer science.

CodePlus was designed as an intervention to address factors that affect girls’ predilections towards college CS pathways and is an example of a non-formal CS outreach programme, a common strategy used to target the adolescent cohort where a sharp drop-off in girls' interest is known to occur. The purpose of the research is to provide a structured approach to evaluating the short-term and longitudinal impact of CS outreach programmes while also investigating the role of pedagogy in the design and delivery of such programmes.

The justification for this study was grounded in the long-standing issue of gender-imbalance in the field of computer science, examined at length in Chapter 2. A meta-analysis of the all-female CS outreach space (Chapter 3) suggested that while many all-female outreach interventions share much by way of design, it also exposed typically small sample sizes, less structured approaches to data collection, and a scarcity of longitudinal studies, giving further justification for the study.

A mixed-methods, concurrent nested design strategy was used to measure the intervention's impact. The research design involved two phases: (1) measuring the short-term impact of the intervention (2) measuring the longitudinal impact of the intervention.

The findings of the study showed significant short-term positive changes in key attitudinal variables relating to the central phenomenon under investigation; computer self-efficacy, perceptions of CS, and future intentions regarding CS pathways. Analysis of short-term qualitative data strongly suggest that the design elements of the intervention contributed to the observed effects. These results were most prominent concerning the pedagogical design aspect of the intervention, in particular the collaborative and constructivist learning methods that are central to the Bridge21 learning model.

The analysis of the longitudinal element of the study had a much smaller sample than the short-term element, nonetheless the analysis suggested that the intervention had an enduring influence on a number of participants, with some electing to study a CS related courses. This is inferred both from data that directly investigates the effect of the intervention and contextual data that highlighted the limited external CS resources and supports available to participants. The small sample size of the interviewees (n=4) allowed for a deeper level of engagement with the participant narratives.

This thesis makes both academic and practical contributions to computer science outreach and the broader area of addressing gender imbalance in the field by meeting the aims of the research through providing;

- A structured meta-analysis of the all-female outreach space
- An assessment of the short and long-term impact of the intervention
- A framework for short-term and longitudinal outreach evaluation
- A deeper understanding of how pedagogical approach in CS outreach can affect intervention outcomes.
- To determine other principal aspects of the design and delivery of all-female computer science outreach programmes that may contribute to improving key attitudinal and intentional variables
- Identifying areas for further research

This chapter seeks to address the aims of research outlined above, present the contributions of the dissertation, acknowledge the limitations of the study, offer directions for future research, and finally some concluding remarks.

8.2 Addressing the Aims of the Research

The aforementioned research aims could be further categorised by two problem statements; PS1 and PS2 (Section 1.1.2). PS1 highlighted a lack of consensus across the all-female CS outreach programme space on measuring impact. A meta-analysis of the space was a logical first step in providing clarity on what data programmes collected and how. The findings of this meta-analysis would in turn influence the development of this study and the instruments used to measure impact.

PS2 identified an opportunity to examine the role of pedagogy in an all-female CS outreach programme. In light of strong criticism of authoritarian and didactic teaching methods common in CS undergraduate courses, and also the common progressive teaching methods shared by the all-female outreach space, pedagogical practice was a potentially under-explored factor that could be examined in the context of this study.

The research questions pertaining to the impact of the intervention on participants are discussed in section 8.2.2.

8.2.1 Meta-Analysis of the All-Female Outreach Space

To identify the common attributes, objectives, and research elements of all-female CS outreach programmes, a systematic literature review was undertaken to identify, evaluate, select, and synthesize results of peer-reviewed, published research in the field. The approach was based on that of Decker et al. (2016) examining the more general area of CS outreach programmes for both male and female participants.

This analysis is presented in Chapter 3 of this dissertation, focusing exclusively on all-female, single sex programmes in the non-formal education space, for participants in the 10-18 age interval. To the author's knowledge there is no peer-reviewed equivalent of this analysis in existence. The analysis was helpful in providing a landscape of the all-female outreach space with 45 papers reviewed and is a key contribution of the dissertation.

Sample sizes for interventions were typically small, with less than 30 participants in the majority of studies, over half of the studies had less than 50 participants, and over two-thirds of studies had less than 100. Modest samples were often acknowledged by the authors as key limitations of studies. Akin to the findings of Decker et al. (2016), longitudinal studies were extremely limited with just 8 of the reviewed papers reporting to have engaged in a longitudinal element. Furthermore, there was considerable variation in the nature of short-term and longitudinal data collected by studies. Attitudes towards computing, interest in computing careers, and perceptions of computing featured most commonly in the studies and while self-reported interest in future study of pursuing study or a career in computing was the most frequently observed category of data collected, just one study claimed to record students' actual choice of college major. As very few of the studies reviewed engaged in a longitudinal element, results relating to career and college intentions were somewhat limited to self-reported, short term outcomes.

Despite the key research limitations outlined above, it was clear that many of the outreach programmes shared practices conducive to creating an encouraging environment for girls. Almost three quarters of the studies reported using female role models as facilitators or instructors, or to deliver career talks suggesting the enlistment of female mentors where possible was considered entirely appropriate and valuably by the programmes. Studies were examined for a clear statement of a teaching style or method and a broad definition of "pedagogy" was taken. While the majority of papers reviewed did not specify any clear or distinct teaching methodology, a number of papers did mention the use of collaborative, team, or group learning (n=8) or distinctive pedagogies such as "Piagetian and Vygotskian perspectives on learning", and constructivism (n=5). Other methods mentioned could arguably be considered as examples of progressive pedagogies such as "hands on", "project based" and "culturally responsive". Overwhelmingly, the programmes took place on college or university campuses which may be due in part to the availability of space to conduct workshops or events, nonetheless a number of studies cited the utilization of a college environment as a key design element of the programmes to further expose participants to CS college life (S. Graham & Latulipe, 2003; Hur et al., 2017):

"Although the venue is not the most important consideration for a project such as this, giving these young women a chance to stay in residence and use the facilities of a university campus is a bonus. All of the sessions were in labs or classrooms on campus. Each student was assigned a university account for use in the lab sessions, but it also allowed the students to access the network or use the lab during their free time. In many ways they experienced life as a university student. When asked "What did you learn at the seminar?" one student wrote: "I learned a lot about how women fit into CS…I kind of got a feel for university life too, and am almost looking forward to it." (S. Graham & Latulipe, 2003, p. 323)

It was encouraging to note that many programmes shared a number of common aspirational goals identified in the papers examined. These included sparking greater interest in computer science, attracting more women to the field, and improving or diversifying perceptions of computer science as a profession. In short, it is the intent of these programmes to benefit participants to these ends and based on the results they report it is likely that they do a great deal of good within the parameters of their resources.

What is more difficult is to quantify is the impact of programmes, particularly in a longitudinal sense, based on the aforementioned limitations inherent the studies examined. This study considered these limitations but also the common good practices of the programmes in the development of the research and intervention design.

8.2.2 Impact on Participants

This research explored the essential impacting elements of the intervention on participants. The results of the study as guided by the three primary research questions are summarised in Table 62:

RQ	**Question**	**Results in Summary**	**Relevant Chapters, Sections**
RQ1	What is the short-term impact of the intervention's approach?	Improved computer self-efficacy. Improved perceptions of CS. Improved intentions towards studying computer science.	Chapter 6, Sections 6.3, 6.5
RQ2	What is the longitudinal impact of the intervention's approach?	Workshops and career talks enable participants to make "informed choice" regarding future CS pathways. Significant association between deeper engagement with programme (additional workshops) and likelihood to choose CS pathways.	Chapter 7, Sections 7.4.2, 7.4.3, 7.4.5, 7.4.6

		Enduring impact of intervention is situated in the context of multifaceted factors and influences.	
RQ3	How did particular elements of the intervention's approach, design and pedagogical considerations affect short-term and longitudinal impact?	Pedagogical design of intervention strongly contributed to the observed effects with collaborative and constructivist learning methods most prominent. Other design aspects such as the on-campus setting and use of female tech professionals had a positive effect on the intervention's impact. The impact of the all-female learning environment was less clear across the data collection stages and warrants further investigation.	Chapter 6, Sections 6.4, 6.5 Chapter 7 Sections 7.4.2, 7.4.3, 7.4.5, 7.4.6

Table 61 Summary of Research Questions and Results

RQ1 was addressed with quantitative statistical analysis of data from a large sample (N=856) of participants in providing clear evidence of impact across key attitudinal and intentional variables.

RQ2 was addressed in a quantitatively led longitudinal survey instrument with a smaller sample (n=75), designed to measure the longitudinal impact of the programme within the context of the multiple factors affecting participants in choosing college pathways.

RQ3 draws on the emergent results from RQ1 and RQ2 and seeks to identify how and to what extent the particular elements of the programme encouraged these results. A qualitative style post-intervention survey (short-term) (n=418) and extensive interviews with four former participants of the programme, allowed for a qualitative consideration of the impacting factors.

The short-term and longitudinal findings pertaining to the research questions will be discussed in turn in the following sub-sections:

8.2.2.1 Short-Term Findings

The objectives of the short-term element of the study were to:

1. To assess the short-term impact of the intervention
2. To gather and analyse data on role of pedagogy in the design
3. To determine other principal aspects of the of the intervention that may contribute to improving key attitudinal and intentional variables
4. To develop a structured framework for assessing the short-term impact of computer science outreach programmes for girls
5. To generate relevant questions for future research

In the short-term element of the study pre-experimental design was first used to quantify the intervention's impact on participants' key attitudinal and intentional variables, while nested, qualitative data was used to triangulate the findings of the quantitative data, in an explanatory capacity, whilst also offering an opportunity to explore and uncover emergent themes.

In collecting quantitative data the instrument used by Sullivan et al. (2015) in the CodePlus pilot study was adopted without further modification. While the instrument was not modified, the methods by which the data were analysed for this study were considerably extended as stated in Section 5.3.1.1.

Results of the quantitative data analysis were positive and indicated significant improvements though paired-t tests in computer self-efficacy, perceptions of CS, and future intentions regarding CS pathways. To access the relationship between participants' computer self-efficacy and intentions to study undergraduate CS, a Spearman's rank-order correlation was run showing a positive association between the two variables. The qualitative data allowed for a triangulation of these findings which gave further validation to the quantitative results.

In addition to the quantitative survey, taken pre and post-intervention, participants were invited to complete a short, handwritten reflective-style survey post-intervention. This instrument was designed as a supplementary questionnaire to provide additional and contextualised data from participants on their perspectives of the intervention through a structured reflection. In order to investigate the impact of the intervention's design elements, the data was analysed through directed content analysis. Baseline and matrix queries allowed for aspects of the intervention's design to be investigated and cross-references between effects and design elements to be made. These procedures allowed for inferences to be made between the design elements of intervention and the intervention effects. The analysis of qualitative data strongly suggested that the design elements contributed to the observed effects. These results were most prominent concerning the pedagogical design aspect of the intervention, in particular the collaborative and constructivist learning methods that are central to the Bridge21 learning model. The impact of design elements such as the all-female learning environment were less distinct.

The quantitative and qualitative findings provided evidence of both the short-term effects of the intervention and an exploration of how elements of the intervention's design contributed to these effects. Accordingly, RQs 1 and 3 (short-term) have been addressed.

8.2.2.2 Longitudinal Findings

The longitudinal aspect of this study was designed in response to a key criticism of the CS outreach space showing a lack of studies that evaluate the lasting impact of interventions. The research aims specific to the longitudinal element of the study were: to examine the effect of the intervention against the multifaceted and complex factors that influence predilections to study computer science or related pathways, and to identify areas for further research.

In this approach, the quantitative longitudinal survey was first used to gather categorical and ordinal data centred on the participants third level choices and influencing factors, while interviews each lasting between 30 and 45 minutes in duration were conducted with participants who were either already studying CS in college or were applying to study CS in college.

The results of the longitudinal survey findings suggested that both the programme workshops and career talks programmes aided participants in making an informed decision as to whether or not they would be interested in pursuing a CS related third level course. Concerning the workshops, 76% of respondents either agreed or strongly agreed with the statement: “My experience with the CodePlus workshops helped me to make an informed decision as to whether or not I would like to study a related third level course”.

Over 64% of respondents rated each individual aspect of the workshops as “valuable” or “very valuable” in terms of helping them to decide whether or not they would be interested in studying a CS related course, these elements were; Learning in an all-female environment, learning in teams, activities and projects related to real-world problems, the mentors/helpers, understanding more about careers in computer science and computing, receiving encouragement to explore careers and study in the area of computing, spending time on the college campus (Section 7.4.2 Table 56). Notably, 84% of respondents rated “understanding more about careers in computer science and computing” and 77% rated “receiving encouragement to explore careers and study in the area of computing” as a “valuable” or “very valuable” aspect of the workshops.

56 respondents indicated receiving a talk in school, at the college or at a tech company in addition to participating in the workshops. Regarding the talks, 68% of respondents either agreed or strongly agreed with the statement: “My experience with the CodePlus career talks helped me to make an informed decision as to whether or not I would like to study a related third level course”. Over 80% of respondents rated each individual aspect of the career talks: Getting to meet a female role model in the industry, understanding more about careers in computer science and computing, learning about the variety of jobs in the industry, learning about the advantages of working in the industry and visiting a tech company, as “valuable” or “very valuable” in terms of helping them to decide whether or not they would be interested in studying a CS related course (Section 7.4.2 Table 57). Notably, 94% of respondents rated “understanding more about careers in computer science and computing” and “learning about the variety of jobs in the industry” as a “valuable” or “very valuable” aspect of the talks

From a sample of 75, 16 respondents indicated that they had applied to study at least one CS related college course. The significant association between the 15 respondents who had participated in additional coding workshops with the programme (CodePlus advanced or InventWeek or both) and applying for a CS related third-level course was a key finding of the survey. This may suggest that a deeper level of engagement is necessary for greater lasting impact, but it is also quite possible that students who attended these additional courses may have been more interested and predisposed to applying for CS in college. This finding warrants further investigation with a larger sample.

For the 16 respondents choosing to apply to CS related college courses, it was helpful to examine the influencing factors based on the approach of (Papastergiou, 2008). “A future with guaranteed employment” emerged as the highest rated factor (42%) with “Someone in my family has influenced me through their experience in the area” and “Strong personal interest in subject area” emerging jointly as the second most commonly rated highest factors (20%). “Strong personal interest in subject area” was also the factor most commonly ranked second by importance. For the respondents who had indicated that they were *not* applying to any CS related courses, it was also helpful to examine the factors that had influenced them. The most commonly rated highest factor (56% of respondents) was “Preference to study other subject(s)”, an understandable and highly personal motivation that the author considers participation in the intervention was unlikely to change. More concerning was the factor that was second most frequently ranked first by respondents (20%); “Unemployment in the profession”. The author considers this finding may reflect some respondents’ lack of exposure to information regarding careers in technology and is in contrast to the respondents who *were* electing to apply for CS related courses. This finding also contradicts the aforementioned 84% of respondents who rated “understanding more about careers in computer science and computing" as "valuable" or "very valuable" aspects of the workshops and 94% of respondents who rated "understanding more about careers in computer science and computing" as valuable" or "very valuable" aspects of the career talks. With a larger sample these factors could be further explored, as 20% of those not electing to study CS in the survey was still a relatively small number.

The findings outlined above investigated the effects of the intervention by asking direct questions of respondents. The survey also gathered contextual data concerning access to role models, formal school CS classes, and other outreach activities. Low baseline levels of exposure and engagement with these categories were reported by respondents but the sample may have been insufficiently large enough to establish significant patterns of association between the additional supports and applying for CS related third level courses. Nonetheless these findings provided a context in which to examine the influence of the intervention, and support a case for such programmes in terms of providing exposure that girls may not otherwise receive.

In longitudinal studies, it is difficult to isolate causes from effects in absolute terms, and one must be cautious to state in deductive terms the impact of the intervention against confounding and mediating variables. It is more likely that there are multiple and complex causes at play and the difficulty in unravelling these causes is a limitation of the survey data. To that end, the interviews provided a means to further examine key factors influencing college pathways that emerged from the short-term longitudinal survey findings. Interviewees were asked about how they had decided to apply for CS related courses, to describe the school and outside school CS activities they had engaged in, to recall their experience of the CodePlus programme, and finally to speak about the reasons for gender-imbalance in the field based on their own perspectives.

The interview data supported many of the quantitative survey data findings, in particular the limited CS resources available to participants. The interviews also offered rich perspectives on the impact of the CodePlus programme in the context of other multifaceted factors and influences. The importance that the four interviewees placed on their participation in the intervention was emphasised, described as an "eye opener" by two interviewees, who along with another interviewee credited CodePlus as one of the main reasons they had elected to study CS. The fourth interviewee identified as a key motivating moment in deciding to study CS as when she first met a female CS student during the workshop.

Certainly the four interviewees all described some antecedent conditions, revealing an early interest in computers, puzzles, or generally how things work. Several interviewees offered that they may not have made the connection between these interests and the path of college CS had it not been for participation in the programme. There were also a number of other important resources that influenced the interviewees such as work experience in tech companies, school coding clubs and support from family, peers, and teachers that were important to consider in the broader context of the group making their college pathway decisions. Some of these supports were made explicit by the interviewees while some were more subtle in nature.

While arguably the interviewees did not offer substantial views on the pedagogical design of the programme, they did make reference to the team-based, scaffolded nature of the learning as a positive aspect of the workshops, distinctively different to formal school learning. The all-female design element of CodePlus prompted richer responses from the interviewees with perspectives offered on how the inclusion of boys tends to affect the levels of participation among girls, based on prior experience. Linked to the all-female environment, two interviewees emphasised the importance of meeting female CS role models through CodePlus in raising their aspirations.

All four interviewees recognised the issue of gender-imbalance in the field of CS as a complex phenomenon with no single solution. Societal norms, historical cultural and gender roles, enduring stereotypes, the gendering of secondary school subjects, a lack of resources, and a lack of role models were offered as contributing factors by the interviewees. These perspectives echoed many of the the themes of the literature and suggested to the author the astuteness of the interviewees in understanding an issue they were still journeying through.

Overall, the survey and interview data provided evidence of both the long-term effects of the intervention and an exploration of how elements of the intervention's design contributed to these effects. Accordingly, RQs 2 and 3 (long-term) have been addressed.

8.3 Limitations

There are a number of distinct limitations pertaining to the study that should be acknowledged.

Foremost, given the practitioner-based nature of the intervention the opportunistic sampling of participants is an area of concern, although this is somewhat mitigated by the large sample size and number of schools (n=55) represented in the initial population study. Programme places were allocated by teachers, meaning that the author had little control over the selection of participants. To that end, it was unlikely that the sample was homogeneous in terms of prior interest, experience, and predilections towards CS, although the short-term quantitative instrument was designed to measure changes in attitudinal and intentional variables whether participants were novices to CS or had some previous experience. Additionally, the longitudinal survey sample suffered from considerable attrition, making it unlikely that those who remained in the study were as representative of the population of the original sample (Cohen et al., 2011, p. 270)

Secondly, the study did not use a control group. The author argues that using a control group would not have been feasible, appropriate or ethical in the context of this study. The intervention was intended to serve as a positive experience to help to scaffold making an "informed decision" regarding pathways in computer science. To recruit a group of students to be deliberately denied this opportunity as a control measure would be of limited value, impractical, and moreover unethical from the author's perspective.

In relation to the longitudinal element of the study, there were several key limitations. The attrition rate from the short-term to the longitudinal survey was high, as is typical in such research, meaning the sample size would not accommodate the same power of statistical testing the short-term data could. Nonetheless the sample was still of a respectable size in the context of educational research studies and yielded some useful findings. Regarding the interviews, the author also fully acknowledges how her prior relationship with the four interviewees may have influenced the narratives that emphasised the impact of CodePlus in the interviewees decision to study CS. The four participants were briefed with an assurance they should answer questions as truthfully as possible and not to try and fit any "agenda" they may have felt the author had. A conscious effort was made during the interviews not to "lead" the interviewees into an agenda but to allow the narratives to emerge and to follow up with questions claims made in support of the intervention. By contrast, it could be argued that this relationship was a key strength of the interview data in the sense that the recordings and transcripts gave a sense of ease and authenticity on the part of the interviewees.

The data collected at this both stages of the study was entirely based on the participants' self-reporting. Participants were neither observed nor given standardised tests to assess their programming ability pre and post-intervention for instance. This factor is somewhat addressed by the application of a mixed methods approach to triangulate and enhance the reliability of the data, reporting on results that contradict the general trends and hypotheses, and presenting qualitative data within appropriate sampling units to convey the authentic voice of participants in the survey and interview data. The author also considers the inherently abstract nature of the key attitudinal and intentional variables such as computer self-efficacy which arguably could only be attained through self-reporting. Much of the data collected in the longitudinal survey was less abstract in nature, such as recording college application choices and the respondents' access to CS resources. It was unlikely that respondents would be motivated to give deliberately false answers to these questions.

The limitations outlined above are not uncommon to pragmatically-based educational research. They do not however, suggest that the findings are not suitable for generalisation, or that they do not form potentially valuable contributions to the field.

8.4 Contributions of the Research

This research makes both academic and practical contributions to CS outreach and the broader area of addressing gender-imbalance in the field. This section states the three main contributions of the thesis in relation to addressing the research problems and research aims. These contributions are:

- A structured meta-analysis of the all-female outreach space
- A framework for short-term and longitudinal outreach evaluation

- A deeper understanding of how pedagogical approach to CS outreach affects participants and further examination of the principal aspects of CS outreach that affect girls.

Section 8.2.1 detailed the meta-analysis of the all-female outreach space undertaken in the study. This is a potentially useful resource for other researchers in the field that the author intends to develop further (see section 8.5). Similarly, the tools and approach to the research untaken in this study could be utilized by similar programmes. The longitudinal element in particular could be adapted by programmes with the capacity to contact participants following an extended period of time. Finally, as the role of pedagogy in CS outreach programmes was previously under-explored, the author considers that the findings of the qualitative short-term data in particular highlighted the role of pedagogical design in contributing to impact as were other aspects of the programme.

While these contributions are constrained to the parameters set by the study, the author considers some of the broader implications of the research. Foremost, there are potential learnings for the delivery of computer science within the formal school curriculum: in an Irish context, the state accredited computer science curriculum has only recently been introduced, with a drive to recruit more schools and teachers to adopt the subject. This research offers an insight into how adolescent girls perceive computer science (before they have a chance to explore the subject), and indeed how considered learning pedagogies can make an impact on engaging female students. The author suggests that earlier opportunities should be given to girls to explore computer science, long before committing to a formal two-year cycle of study, or to put it another way, girls should be offered “tasters” of the course materials much earlier in the formal school cycle. The importance of female role models for girls also raises some questions on ensuring gender-balance on the recruitment of CS teachers which should be given due consideration by key stakeholders. Finally, as approximately a third of all schools in Ireland are currently single-sex environments, special initiatives could be taken to support all-female schools in adopting computer science as a grass-roots strategy to broaden the participations of young women and begin to the level the playing field. While the above examples pertain to the Irish education system, the author considers how many of these strategies would be more universally applicable. Although examined in the literature review, it was beyond the scope of this study to explore the design aspects of college level computer science and how favourable the teaching methods are to female students. Nonetheless, this study offers some learnings on the benefits of collaborative and constructivist pedagogies that could impact on the recruitment and retention of women to college CS programmes.

Secondly, there were two key areas of concern with broader implications that the longitudinal stage of the study highlighted. The first was the stark lack of opportunities that were available to the participants to engage in CS activities in non-formal education settings. The author recommends that in addition to the drive to roll-out CS as a formal state accredited subject, key stakeholders should look to providing more non-formal educational opportunities for girls and young women to explore CS in their communities. Partnerships with pre-existing organisations could be highly beneficial to this cause such as libraries, scout and guide groups, youth groups etc. Due consideration may also need to be given to removing monetary barriers to participations such as cost and equipment. There may also be social-cultural barriers to participation such as negatively held perceptions of computing or male-dominated groups that should also be considered in the marketing and design of such programmes.

Finally, the interviews highlighted multiple instances of misogyny and male-bias that all four young women had experienced in the context of their personal CS pathways. From the unintentional bias that the women sensed in the presence of male peers who “took over” or were more likely to be listened to by teachers and instructors, to outright verbal hostility or “heckling” from male students in college classes, sadly this is a longstanding issue in the research context that needs to tackled head-on. While misogyny and sexism is behaviour that is not confined to the field of computer science, it is certainly an exacerbating and enduring factor affecting women's participation in the field. To this end, the author urges schools, non-formal education initiatives, and college faculties to be vigilant, to provide safe and equitable environments for girls and women, and to hold men and boys accountable for their behaviour. Two important examples of institutions who took practical steps to combat such behaviour are that of Harvey Mudd College and Carnegie Mellon University (See Section 2.6.2) and provide some good guidelines to follow. While this is the testimony of just four young women in the context of this study, the author strongly suspects that there are many similar stories out there and a need for greater education on gender-sensitivity in the area.

8.5 Future Research

There are a number of potential avenues for the research to be extended.

The meta-analysis of the all-female outreach space could be further developed, peer reviewed and published for the benefit of other researchers. The development of the analysis was born from the author's inability to find such a resource in the early stages of the study and she considers it likely that fellow researchers may find use for such an analysis in the future.

A fundamental limitation of the longitudinal survey data was the limited sample size. This survey can be re-issued to CodePlus alumni over the coming years to expand the sample size allowing for greater statistical power and representation of the population size to establish patterns of association and causality. The programme has recently been awarded a research grant to extend its reach across three Irish universities. This will effectively multiply the annual capacity of the programme threefold and it is the intention of the programme team to continue to assess the longitudinal impact of the programme with the larger population sample.

The four interviews offered rich and meaningful perspectives from CodePlus alumni on the impact of the programme against the complex network of mediating factors affecting a decision to study CS. The study was limited in the number of interviews that could be conducted as the process of data collection, transcription and analysis is time consuming. Nonetheless, it was during the interviews that some of the most insightful aspects of the research emerged, presenting the voice of the participants in its most authentic form. Interviewing more female CS college students, and not just those who attended the programme, would reveal much about the pathways to CS that young women take. This type of research would be akin to the highly influential "Unlocking the Computer Clubhouse" by Margolis and Fisher (2002) who interviewed over 100 male and female CS students over a four-year period at Carnegie Mellon University to capture the experience of the women in computing. Given the landscape of the expanding tech industry in Ireland, this type of research would certainly be of interest to corporate and academic stakeholders.

An interesting finding of the longitudinal survey data was that the career talks and workshops were closely ranked in terms of value by respondents. Two interviewees also placed significant emphasis on meeting a female CS student or professional as a key moment of "realisation" regarding their own future in CS. This raised questions on the potential of career talks as a meaningful contribution to encouraging young women. To that end, instruments could be developed to assess the impact of stand-alone career talks as an ancillary activity of the programme.

8.6 Concluding Remarks

This dissertation describes the approach of a non-formal CS outreach programme "CodePlus", designed as an intervention programme to address factors that affect girls' predilections to study computer science and related courses. It shared many of the common aspects of CS outreach programmes for girls including an all-female environment, use of female role models and took place on a college campus. The intervention is also an applied example of an established pedagogical model for teaching and learning (Bridge21). The model's key components are: project-based, technology-mediated learning; a structured team-based pedagogy; recognition of social learning protocols, and a constructivist rather than an instructive method of teaching.

CS outreach programmes for girls share the common goal of supporting young women in exploring pathways to computer science, an established strategy in the move to address the long-leaking pipeline of women at all strata of computing. Such interventions are not a silver bullet but they are a good place to start. To offer girls an opportunity to explore CS for themselves in an engaging and safe environment allows them to decide for themselves whether this is a pathway that sparks their enthusiasm and aspirations or to put it in the words of one CodePlus alumni:

"If you were someone like me who didn't have a role model working in tech and you were interested, you came across someone that did kind of change your life at the end of the day".

CS outreach programmes for girls are proponents in improving the representation of women in computing. This dissertation set out to demonstrate how effective CS outreach programmes can be, by evaluating the impact of CodePlus in the short and long-term with a structured research framework. The results showed significant short-term positive changes in key attitudinal variables relating to the central phenomenon under investigation and affirmed the efficacy of the intervention's design elements, particularly its pedagogical underpinnings. The results of the longitudinal element of the study suggest that the intervention had an enduring influence on a number of participants electing to study a CS related course.

This dissertation humbly offers its research approach and findings to sister programmes and initiatives that may be assured of their potential to support and encourage young women towards pathways in CS.

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10 Appendices

10.1 Appendix A: Meta-Analysis of All-Female CS Outreach Programme Studies (List of Papers Reviewed)

Author(s)	**Title**	**Year**
AlHumoud,Sarah Al-Khalifa, Hend S Al-Razgan, Muna Alfaries, Auhood	Using App Inventor and LEGO mindstorm NXT in a Summer Camp to attract High School Girls to Computing Fields	2014
Almjeld, Jen	Not Your Mother's Tech Camp: Rebooting Girls' Technology Camps to Equip the Next Generation of Technofeminists	2019
Black, Johnathan Curzon, Paul Myketiak, Chrystie McOwan, Peter W.	A Study in Engaging Female Students in Computer Science Using Role Models	2011
Buechley, Leah Eisenberg, Mike Catchen, Jaime Crockett, Ali	The LilyPad Arduino: Using Computational Textiles to Investigate Engagement, Aesthetics, and Diversity in Computer Science Education	2008
Burge, Janet E. Gannod, Gerald C. Doyle, Maureen Davis, ,Karen C.	Girls on the Go: A CS Summer Camp to Attract and Inspire Female High School Students	2013
Carmichael, Gail	Girls, Computer Science, and Games	2008
Countryman, Jeri Feldman, Allegra Kekelis, Linda Spertus, Ellen	Developing a hardware and programming curriculum for middle school girls	2002
Craig, Annemieke Coldwell-Neilson, Jo Beekhuyzen, Jenine	Are IT Interventions for Girls a Special Case?	2013
Craig, Annemieke Fisher, Julie Forgasz, Helen Lang, Catherine	Evaluation Framework Underpinning the Digital Divas Programme	2011
Craig, M. Horton, D.	Gr8 Designs for Gr8 Girls: A Middle-School Program and its Evaluation	2009
Denner, J. Werner, L. Ortiz, E.	Computer games created by middle school girls: Can they be used to measure understanding of computer science concepts?	2012
Doerschuk, Peggy	Pilot Summer Camps in Computing for Middle School Girls: From Organization Through Assessment	2007
Fisher, Julie Lang, Catherine Craig, Annemieke Forgasz, Helen	If girls aren't interested in computing can we change their minds?	2015
Frieze, Carol	Diversifying the images of computer science: undergraduate women take on the challenge!	2005

Gannod, Gerald C. Burge, Janet E. McIe, Victoria Doyle, Maureen Davis, Karen C	Increasing Awareness of Computer Science in High School Girls	2014
Graham, Sandy Latulipe, Celine	CS Girls Rock: Sparking Interest in Computer Science and Debunking the Stereotypes	2003
Heo, M. Myrick, L. M.	The girls' computing club: Making positive changes in gender inequity in computer science with an informal, female learning community	2009
Hulsey, Caitlin Pence, Toni B. Hodges, Larry F.	Camp CyberGirls: Using a Virtual World to Introduce Computing Concepts to Middle School Girls	2014
Hunter, Alison Boersen, Raewyn	Out from the Shadows: Encouraging Girls in New Zealand into IT Careers. ”	2017
Hur, Jung Won Andrzejewski, Carey E. Marghitu, Daniela	Girls and computer science: experiences, perceptions, and career aspirations	2017
Jung, Eunjin Apedoe, Xornam S.	Changing Young Women's Perceptions of CS via Outreach	2013
Kamberi, Shahnaz	Exposing Girls to Computer Science: Does the AllGirl Model Really Work?	2017
Kelleher, Caitlin Pausch, Randy	Lessons Learned from Designing a Programming System to Support Middle School Girls Creating Animated Stories	2006
Lang, Catherine Craig, Annemieke Fisher, Julie Forgasz, Helen	Creating Digital Divas – Scaffolding Perception Change Through Secondary School and University Alliances	2010
Maciel, Cristiano Bim, Silvia Amelia da Silva Figueiredo, Karen	Digital Girls Program – Disseminating Computer Science to Girls in Brazil	2018
Madrigal, Veronica Yamaguchi, Ryoko Hall, Adam Burge, Jamika	Promoting and Supporting Computer Science Among Middle School Girls of Color	2020
Marc, Gabriela Kaufman, Samuel J. Jaihee, Kate Lee Black,Rebecca W. Dourish, Paul Hayes, Gillian R. Richardson, Debra J.	Design and Evaluation of a Computer Science and Engineering Course for Middle School Girls	2010
Mason, Raina Cooper, Graham Comber, Tim	Girls get IT	2011
McFarlane, Dana Redmiles, Elissa M.	Get Paid to Program: Evaluating an Employment-Aware After-School Program for High School Women of Color	2020
Outlay, Christina N. Platt, Alana J. Conroy, Kacie	Getting IT Together: A Longitudinal Look at Linking Girls' Interest in IT Careers to Lessons Taught in Middle School Camps	2017
Pivkina, I. Pontelli, E. Jensen, R. Haebe, J.	Young Women in Computing: Lessons Learned from an Educational & Outreach Program	2009

Pollock, Lori McCoy, Kathleen Carberry, Sandra Hundigopal, Namratha You, Xiaoxin	Increasing High School Girls' Self Confidence and Awareness of CS through a Positive Summer Experience∗	2004
Robinson, A. Perez-Quinones, M.A. Scales, G	African-american Middle school Girls: Influences on Attitudes toward Computer Science	2016
Robinson, Ashley Pérez-Quiñones, Manuel A.	Underrepresented Middle School Girls: On the Path to Computer Science through Paper Prototyping	2014
Rodger, Susan H. Walker, Ellen L.	Activities to attract high school girls to computer science	1996
Sabin, Mihaela Snow, Paul Laturnau, Mary	Evaluation of a computing and engineering outreach program for girls in grades 8--10	2015
Scott, A.	Broadening Participation in Computing: Examining Experiences of Girls of Color	2017
Seraj, Mazyar Katterfeldt, Eva-Sophie Autexier, Serge Drechsler, Rolf	Impacts of Creating Smart Everyday Objects on Young Female Students' Programming Skills and Attitudes	2020
Seraj, Mazyar Katterfeldt, Eva-Sophie Bub, Kerstin Autexier, Serge Drechsler, Rolf	Scratch and Google Blockly: How Girls' Programming Skills and Attitudes are Influenced	2019
Starrett, Courtney, Doman, Marguerite Garrison, Chlotia, Sleigh, Merry	Computational Bead Design: A Pilot Summer Camp in Computer Aided Design and 3D Printing for Middle School Girls	2015
Sullivan, Kevin Byrne, Jake Rowan Bresnihan, Nina O'Sullivan, Katriona Tangney, Brendan	CodePlus—Designing an after school computing programme for girls	2015
Thangarajah, Pamini Keshavjee, Mo Smith, Michele	Explore IT: An Information and Communication Technology Outreach for Grade Nine Girls	2014
Vachovsky, Marie E. Wu, Grace Chaturapruek, Sorathan Russakovsky, Olga Sommer, Richard Fei-Fei, Li	Towards More Gender Diversity in CS through an Artificial Intelligence Summer Program for High School Girls	2016
Wang, Chia Q. Tang, Carmen Zhang, Liyang Cukierman, Diana	Try/CATCH - A CS Outreach Event Organized by Female University Students for Female High School Students: A Positive Experience for All the Parts Involved	2012
Webb, Heidi C. Rosson, Mary Beth	Exploring Careers While Learning Alice 3D: A Summer Camp for Middle School Girls	2011

10.2 Appendix B: Speaker Slides Template

BRIDGE21
THE POWER OF LEARNING

My life as a………..

My name here

Company or Organisation
Logo here

Me in school...

- What kind of student you were

- Subjects at schools
- (STEM) or lack of?
- Other subjects you liked

- School in the 80s, 90s or Noughties

After School College....

- 3rd level

- College life
- Societies, friends

After College....

- 1st jobs
- Career changes
- Living abroad

What do I do now....

- Your Job
- Creativity, Teamwork
- What does a typical day look like for you?

Stories from work...

- Lifestyle
- Work-life balance
- Travel
- Money!!

What I am most proud of...

- Professional achievements
- Addressing gender imbalance/inequality
- Diversity in Tech
  (LGBTQ, ethnicity, ageism, socio-ecomonic etc...)

Questions...

10.3 Appendix C: Short Term Survey

CP Workshop Survey

Start of Block: Default Question Block

Q1

Dear Student,

Your school has agreed to participate in the CodePlus research project. a collaboration between the the School of Computer Science & Statistics and the Trinity Access programme in Trinity College Dublin. The principal investigator is Grace Lawlor supervised by Professor Brendan Tangney.

.

The overall aim of the programme is to provide a learning experience for young female students to explore potential careers related to computer science through the use of technology and teamwork. The programme seeks to positively engage students and encourage them to raise their personal learning aspirations. This research involves collecting both short and long term data to evaluate the impact of the programme which is explained in more detail below.

During the programme you will be involved in different innovative learning experiences and researchers from Trinity College would like to collect information about your views on those experiences. You can choose whether or not you would like to participate in this research, which could involve the following: Interactions between you and your classmates working together may be observed and recorded; interactions between you and your teacher may be recorded; you may be asked to complete questionnaires and feedback forms at different times during the programme; you may also be selected to take part in an interview either individually, or with a small group of your classmates, which will last between 20 and 30 minutesThe project seeks to examine long term impact so we are asking for participants and their parents to give their permission to be contacted in the future (approximately 2 years following participation in the programme).

All information that is collected by the researchers will be anonymised (all names will be removed) and stored in Trinity College, Dublin. For the questionnaires and grade information, each student will be allocated a unique identification number, which will permit the researchers to look at changes over time, but will not be able to be used to identify any student by name. In the unlikely event that information about illegal activities should emerge during the study, the researchers will have to inform the relevant authorities. The results of the research are likely to be used in lectures, Ph.D. theses, conference presentations and journal articles, but you or your school will not be identified.

Your participation in the research aspect of the programme is voluntary and you can change your mind about it at any time – in that case we will not use any information already collected about you, but you can continue to be involved with any of the CodePlus activities that are offered to your school.

From time to time, we may also record video footage and images of you, your classmates and your teachers at work, which might be used in communications and promotional/marketing material about the CodePlus project, or in dissemination activities such as conference presentations. You have the right to be anonymous; therefore your name will not appear alongside any images/video footage. Please keep in mind that you can change your mind at any time about the use of your image, and in that case we will not use any images/video footage associated with you.

If you have any questions, please do not hesitate to ask your teacher, or programme coordinator Grace Lawlor grace@bridge21.ie.

Agreeing to participate means you agree to the following points

• I have read, or had read to me, a document providing information about this research and this consent form.
• I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
• I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
• I understand that if I make illicit activities known, these will be reported to appropriate authorities.
• I understand that I may stop electronic recordings at any time, and that I may at any time, even subsequent to my participation have such recordings destroyed (except in situations such as above).
• I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
• I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
• I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
• I understand that my participation is fully anonymous and that no personal details about me will be recorded.
• If the research involves viewing materials via a computer monitor I understand that if I or anyone

in my family has a history of epilepsy then I am proceeding at my own risk.
• I have received a copy of this agreement

◯ I consent to my participation (continue to survey) (1)

◯ I do not consent to my participation (leave survey) (2)

Skip To: End of Survey If Dear Student, Your school has agreed to participate in the Trinity Access 21 (TA21) research proj... = I do not consent to my participation (leave survey)

End of Block: Default Question Block

Start of Block: Demographics

Q2 Please enter your full name (First name, Surname)

____

Q3 Please enter your email adress

____

Q4 Please select an option for your gender below

◯ Male (1)

◯ Female (2)

◯ Non-binary/Other (3)

Q5 Please enter your date of birth (dd/mm/yyyy)

____

Q6 What class/year are you in?

○ 1st Year (1)

○ 2nd Year (2)

○ 3rd Year (3)

○ 4th Year (4)

○ 5th Year (5)

○ 6th Year (6)

Q7 Select your school name from the list below

▼Alexandra College (1) ... Other (21)

Display This Question:

If Select your school name from the list below = Other

Q8 Please enter your school name

____

End of Block: Demographics

Start of Block: School Results

Q9 What result did you get/or do you expect to get in Junior Certificate Maths?

	A (1)	B (2)	C (3)	D (4)	E (5)	F (6)
Higher level (1)	○	○	○	○	○	○
Ordinary level (2)	○	○	○	○	○	○
Foundation level (3)	○	○	○	○	○	○

End of Block: School Results

Start of Block: Computing Experience

Q10 Do you have access to a desktop/laptop or tablet computer at home?

○ Yes (1)

○ No (2)

Display This Question:

If Do you have access to a desktop/laptop or tablet computer at home? = Yes

Q11 If you answered "yes" to the previous question is/are the device(s) for shared or personal use?

○ Shared use (1)

○ Personal use (2)

End of Block: Computing Experience

Start of Block: Computer Use

Q12 How often do you use these types of software on average per week?

	Never (1)	Less than 1 hour (2)	Between 1 and 5 hours (3)	Between 5 and 10 hours (4)	10+ hours (5)
Word processing, e.g. Word, Google Docs (1)	○	○	○	○	○
Email (2)	○	○	○	○	○
Presentation software, e.g. PowerPoint, Prezi (3)	○	○	○	○	○
Spreadsheet, e.g. Excel (4)	○	○	○	○	○
Database, e.g. Access (5)	○	○	○	○	○
Web authoring, e.g. Dreamweaver, WordPress (6)	○	○	○	○	○
Multimedia applications, e.g. Movie maker, iPhoto, Photoshop, etc. (7)	○	○	○	○	○

Q13 During the past week, how much time did you spend on your computer (not including a mobile phone) doing the following activities?

	None (1)	Less than 1 hour (2)	Between 1 and 5 hours (3)	Between 5 and 10 hours (4)	10+ hours (5)
Doing homework (1)	o	o	o	o	o
Searching for information (not homework related) (2)	o	o	o	o	o
Developing websites (3)	o	o	o	o	o
Writing computer programs (4)	o	o	o	o	o

End of Block: Computer Use

Start of Block: Self-Efficacy

Q14 Please select the response that best represents your view

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
I enjoy computer programming (1)	○	○	○	○	○
I often have difficulties when trying to learn how to use new computer software/apps/programs (2)	○	○	○	○	○
I am very confident in my ability to computer program (3)	○	○	○	○	○
Computer programming is far too complicated for me (4)	○	○	○	○	○
I find computer programming very easy (5)	○	○	○	○	○
As far as computer prommaming goes, I feel less competent than my classmates (6)	○	○	○	○	○
I usually find it easy to learn how to use new computer software/apps/programs (7)	○	○	○	○	○
Computer programming frightens me (8)	○	○	○	○	○
I consider myself a more skilled computer programmer than most of my classmates (9)	○	○	○	○	○

I am very unsure of my ability to program computers (10)	○	○	○	○	○

Q15 Please rate your ability to program a computer on the following scale?

- ○ Excellent (1)
- ○ Good (2)
- ○ Average (3)
- ○ Poor (4)
- ○ Very Poor (5)

End of Block: Self-Efficacy

Start of Block: Computer Knowledge

Q16 Please indicate your level of knowledge of the following computer languages

	None (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Java (1)	o	o	o	o	o
C (2)	o	o	o	o	o
C++ (3)	o	o	o	o	o
Scratch (4)	o	o	o	o	o
HTML (5)	o	o	o	o	o
Python (6)	o	o	o	o	o
Alice (7)	o	o	o	o	o
App Inventor (8)	o	o	o	o	o

End of Block: Computer Knowledge

Start of Block: Future Plans

Q17 How likely is it that you will go to college/university?

- Very likely (1)
- Likely (2)
- Uncertain (3)
- Unlikely (4)
- Very unlikely (5)

Q18 How confident are you in your ability to get accepted to college/university?

- Very confident (1)
- Confident (2)
- Uncertain (3)
- Not very confident (4)
- Not at all confident (5)

Q19 How likely is it that will apply to study a computer science related course in college or university?

- Very likely (1)
- Likely (2)
- Uncertain (3)
- Unlikely (4)
- Very Unlikely (5)

Q20 Has anyone in your immediate family attended, or is anyone currently attending, 3rd level? Please state who

____

Q21 Below is a list of college courses. Please indicate how good a choice each would be as a college course for you or someone like you

	Very Good (1)	Good (2)	Fair (3)	Poor (4)	Bad (5)
Environmental Science (1)	○	○	○	○	○
Economics (2)	○	○	○	○	○
Communications Studies (3)	○	○	○	○	○
Engineering (4)	○	○	○	○	○
Biology / Biological Sciences (5)	○	○	○	○	○
Education (6)	○	○	○	○	○
Psychology (7)	○	○	○	○	○
Computing / Computer Science / Information Technology (8)	○	○	○	○	○
Design (9)	○	○	○	○	○
Business / Management / Marketing (10)	○	○	○	○	○
Other (11)	○	○	○	○	○

Display This Question:

If Below is a list of college courses. Please indicate how good a choice each would be as a college... [Other] (Recode) Is Not Empty

Q22 If you selected "other" please specify which course

____

End of Block: Future Plans

Start of Block: Course Perceptions

Q23 How confident are you in your ability to get accepted to college/university to study a computer science related course?

- ◯ Very confident (1)
- ◯ Confident (2)
- ◯ Uncertain (3)
- ◯ Not very confident (4)
- ◯ Not at all confident (5)

Q24 Do you think a university course in computer science involves...

	Strongly Agree (1)	Agree (2)	Uncertain (3)	Disagree (4)	Strongly disagree (5)
Doing a lot of mathematics (1)	○	○	○	○	○
Spending a lot of time programming (2)	○	○	○	○	○
Learning different programming languages (3)	○	○	○	○	○
Working in groups (4)	○	○	○	○	○
Being creative (5)	○	○	○	○	○
Solving problems (6)	○	○	○	○	○
Learning how to communicate (7)	○	○	○	○	○
Designing computer games (8)	○	○	○	○	○
Spending a year abroad (9)	○	○	○	○	○

End of Block: Course Perceptions

Start of Block: Computer Science Career

Q25 For each of the following aspects, please indicate the extent to which you believe that the Computer Science profession...

	Not at all (1)	To a small degree (2)	To a reasonable degree (3)	To a large degree (4)	To a very large degree (5)
Is creative (1)	○	○	○	○	○
Is competitive (2)	○	○	○	○	○
Is interesting (3)	○	○	○	○	○
Is difficult (4)	○	○	○	○	○
Is well-paid (5)	○	○	○	○	○
Is prestigious (6)	○	○	○	○	○
0ffers the opportunity to engage in a variety of fields (7)	○	○	○	○	○
Demands that someone engages in computer programming (8)	○	○	○	○	○
Involves working in a team (9)	○	○	○	○	○
Involves problem solving (10)	○	○	○	○	○

Involves doing a lot of mathematics (11)	○	○	○	○	○
Involves being useful to other people (12)	○	○	○	○	○

Q26 How much do you agree with the following statements?

	Strongly Disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Computer Science is a science more appropriate for men than for women (1)	◯	◯	◯	◯	◯
Men are more likely to succeed in the IT profession than women (2)	◯	◯	◯	◯	◯
Men are by nature more inclined towards Computer Science than women (3)	◯	◯	◯	◯	◯
Computer Science involves mainly programming. (4)	◯	◯	◯	◯	◯
Computer Science degrees deal mostly with programming. (5)	◯	◯	◯	◯	◯
Programming is closely related to Computer Science (6)	◯	◯	◯	◯	◯

When I think of Computer Science degrees I think of geeks. (7)	○	○	○	○	○
When I think of Computer Science degrees I think of nerds. (8)	○	○	○	○	○
Computer Science is for geeks and nerds. (9)	○	○	○	○	○
I consider myself a skilled computer user. (10)	○	○	○	○	○
As far as computers go, I feel competent. (11)	○	○	○	○	○
I am very confident in my ability to use computers. (12)	○	○	○	○	○
I would like to do a degree in Computer Science. (13)	○	○	○	○	○
I plan to do a degree in Computer Science. (14)	○	○	○	○	○

I intend to do a degree in Computer Science (15)	○	○	○	○	○
I have a friend or family member in the Computer Science industry. (16)	○	○	○	○	○
I know a successful person that has a Computer Science related degree. (17)	○	○	○	○	○
I know someone with a Computer Science degree (18)	○	○	○	○	○
'll need programming for my future work. (19)	○	○	○	○	○
I study programming because I know how useful it is. (20)	○	○	○	○	○
Knowing programming will help me earn a living. (21)	○	○	○	○	○

Computer science is a worthwhile and necessary subject. (22)	○	○	○	○	○
I'll need a firm mastery of programming for my future work. (23)	○	○	○	○	○
I will use programming in many ways throughout my life. (24)	○	○	○	○	○
Programming is of no relevance to my life. (25)	○	○	○	○	○
Programming will not be important to me in my life's work. (26)	○	○	○	○	○
I see computer science as a subject I will rarely use in my daily life. (27)	○	○	○	○	○
Taking computer science courses is a waste of time. (28)	○	○	○	○	○

In terms of my adult life it is not important for me to do well in computer science in college. (29)	○	○	○	○	○
I expect to have little use for programming when I get out of school. (30)	○	○	○	○	○

End of Block: Computer Science Career

Start of Block: Block 10

Q27 Please select an option below

○ I wish to submit my survey (1)

○ I do not wish to submit my survey (2)

End of Block: Block 10

10.4 Appendix D: Longitudinal Study

CP Longitudinal Survey

Start of Block: Information Sheet

Q1
Dear Student,

Your school has agreed to participate in the CodePlus research project. a collaboration between the the School of Computer Science & Statistics and the Trinity Access programme in Trinity College Dublin. The principal investigator is Grace Lawlor supervised by Professor Brendan Tangney.

.

The overall aim of the programme is to provide a learning experience for young female students to explore potential careers related to computer science through the use of technology and teamwork. The programme seeks to positively engage students and encourage them to raise their personal learning aspirations. This research involves collecting both short and long term data to evaluate the impact of the programme which is explained in more detail below.

During the programme you will be involved in different innovative learning experiences and researchers from Trinity College would like to collect information about your views on those experiences. You can choose whether or not you would like to participate in this research, which could involve the following: Interactions between you and your classmates working together may be observed and recorded; interactions between you and your teacher may be recorded; you may be asked to complete questionnaires and feedback forms at different times during the programme; you may also be selected to take part in an interview either individually, or with a small group of your classmates, which will last between 20 and 30 minutes. The project seeks to examine long term impact so we are asking for participants and their parents to give their permission to be contacted in the future (approximately 2 years following participation in the programme).

All information that is collected by the researchers will be anonymised (all names will be removed) and stored in Trinity College, Dublin. For the questionnaires and grade information, each student will be allocated a unique identification number, which will permit the researchers to look at changes over time, but will not be able to be used to identify any student by name. In the unlikely event that information about illegal activities should emerge during the study, the researchers will have to inform the relevant authorities. The results of the research are likely to be used in lectures, Ph.D. theses, conference presentations and journal articles, but you or your school will not be identified.

Your participation in the research aspect of the programme is voluntary and you can change your mind about it at any time – in that case we will not use any information already collected about you, but you canl continue to be involved with any of the CodePlus activities that are offered to your school.

From time to time, we may also record video footage and images of you, your classmates and your teachers at work, which might be used in communications and promotional/marketing material about the CodePlus project, or in dissemination activities such as conference presentations. You have the right to be anonymous; therefore your name will not appear alongside any images/video footage. Please keep in mind that you can change your mind at any time about the use of your image, and in that case we will not use any images/video footage associated with you.

If you have any questions, please do not hesitate to ask your teacher, or programme coordinator Grace Lawlor grace@bridge21.ie.

Agreeing to participate means you agree to the following points

- I have read, or had read to me, a document providing information about this research and this consent form.
- I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I understand that I may stop electronic recordings at any time, and that I may at any time, even subsequent to my participation have such recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- If the research involves viewing materials via a computer monitor I understand that if I or anyone

in my family has a history of epilepsy then I am proceeding at my own risk.
• I have received a copy of this agreement

◯ I consent to my participation (continue to survey) (1)

◯ I do not consent to my participation (exit survey) (2)

Skip To: End of Survey If Dear Student, Your school has agreed to participate in the Trinity Access 21 (TA21) research proj... = I do not consent to my participation (exit survey)

End of Block: Information Sheet

Start of Block: Demographics

Q2 Please enter your name (First name, Surname)

____

*

Q3 What is your date of birth (dd/mm/yyyy)

____

Q4 Select your school name from the list below

▼Alexandra College (1) ... Other (22)

Display This Question:

If Select your school name from the list below = Other

Q5 Please enter your school name below

Q6 Part of the purpose of this research is to examine long-term impact on participants. Please select your preference on how to contact you in the future.

- ○ I give my permission to be contacted by email alone (1)
- ○ I give my permission to be contacted by phone alone (2)
- ○ I give my permission to be contacted by phone and email (3)
- ○ I do not give my permission to be contacted in the future either by phone or email (4)

Display This Question:

If Part of the purpose of this research is to examine long-term impact on participants. Please selec... = I give my permission to be contacted by email alone

Or Part of the purpose of this research is to examine long-term impact on participants. Please selec... = I give my permission to be contacted by phone and email

Q7 Please enter your email address (the one you intend you use when you finish school)

____

Display This Question:

If Part of the purpose of this research is to examine long-term impact on participants. Please selec... = I give my permission to be contacted by phone alone

Or Part of the purpose of this research is to examine long-term impact on participants. Please selec... = I give my permission to be contacted by phone and email

Q8 Please enter your mobile phone number eg; 0871234567

____

End of Block: Demographics

Start of Block: After School Plans

Q9 Are you planning on attending a third level (college or university) course following completion of secondary school?

◯ Yes (1)

◯ No (2)

◯ I'm not sure (3)

Skip To: End of Survey If Are you planning on attending a third level (college or university) course following completion o... = No

Skip To: End of Survey If Are you planning on attending a third level (college or university) course following completion o... = I'm not sure

Q10 Select which subject areas you have applied to study (select all that are relevant)

- ☐ Arts and Humanities (1)
- ☐ Social sciences, journalism and information (2)
- ☐ Business, administration and law (3)
- ☐ Education (6)
- ☐ Natural sciences, mathematics and statistics (7)
- ☐ Information and Communication Technologies (ICTs) (8)
- ☐ Engineering, manufacturing and construction (9)
- ☐ Agriculture, forestry, fisheries and veterinary (10)
- ☐ Health and welfare (11)
- ☐ Services (12)
- ☐ Generic programmes and qualifications (13)
- ☐ Other (16)

Display This Question:

If Select which subject areas you have applied to study (select all that are relevant) = Other

Q11 Please specify other area(s) of study

____

Q12 Select in order of importance which factors that influenced you to choose which courses to study
(select all that apply in order of importance 1=most important)

______ A future with guaranteed employment (1)
______ Someone in my family has influenced me through their experience in the area (2)
______ Strong personal interest in subject area (9)
______ Well-paid jobs in the area (3)
______ Secondary school experience with subject (5)
______ Other (8)

Display This Question:

If Select in order of importance which factors that influenced you to choose which courses to study... [Other] Is Not Empty

Q13 If you selected other, please specify any other factors that infuenced you in choosing which courses to study

____

End of Block: After School Plans

Start of Block: Computer Science, Computing and IT courses

Q14 Have you applied to study any course or courses related to computer science, computer engineering, computing or IT?

- ◯ Yes (1)
- ◯ No (2)

Display This Question:

If Have you applied to study any course or courses related to computer science, computer engineering... = No

Q15 Select in order of importance the reasons why you did not consider choosing a course related to computer science, computer engineering, computing or IT.

______ Preference to study other subject(s) (2)
______ Dislike of computers and preference towards more people-based professions (3)
______ Studying Computer Science or working in the IT profession seems too difficult (10)
______ Lack of prior opportunities to get involved with computers in the home or school environment (11)
______ Unemployment in the profession (12)
______ Other (9)

Display This Question:

If Select in order of importance the reasons why you did not consider choosing a course related to c... [Other] Is Not Empty

Q16 If you selected other, please specify any other factors that infuenced you in not considering a computer science, computer engineering, computing or IT related course?

____

End of Block: Computer Science, Computing and IT courses

Start of Block: Block 1

Display This Question:

If Have you applied to study any course or courses related to computer science, computer engineering... = Yes

Q17 Select in order of importance which factors that influenced you to choose a computer science, computer engineering, computing or IT related course
(select all that apply in order of importance 1=most important)

______ Profession of the future with guaranteed employment (1)
______ Strong personal interest in computers (2)
______ Someone in my family has influenced me through their experience in the area (3)
______ Well-paid jobs (4)
______ Secondary school experience with subject (10)
______ Other (9)

Display This Question:

If Have you applied to study any course or courses related to computer science, computer engineering... = Yes

Q18 Please select all relevant computer science, computer engineering, computing or IT related courses that you have applied for

- ☐ Computer Engineering level 6 (higher certificate) (1)
- ☐ Computing level 6 (higher certificate) (2)
- ☐ Computing and Multimedia level 6 (higher certificate) (3)
- ☐ Electronic and Computer Engineering level 6 (higher certificate) (4)
- ☐ Computing level 7 (ordinary degree) (5)
- ☐ Information Technology level 7 (ordinary degree) (6)
- ☐ Business and IT level 7 (ordinary degree) (7)
- ☐ Computing in Interactive Digital Art and Design level 7 (ordinary degree) (8)
- ☐ IT Management level 7 (ordinary degree (9)
- ☐ Computing with Games Development level 7 (ordinary degree) (10)
- ☐ Computing level 8 (higher degree) (11)
- ☐ Psychology and Computing level 8 (higher degree) (12)
- ☐ Computer Science level 8 (higher degree) (13)
- ☐ Computer Games Development level 8 (higher degree) (14)
- ☐ Computing in Interactive Digital Art and Design level 8 (higher degree) (15)
- ☐ Cloud Computing level 8 (higher degree) (16)
- ☐ Business Computing level 8 (higher degree) (17)
- ☐ Computer Networks and Systems Management level 8 (higher degree) (18)
- ☐ Electronic and Computer Engineering level 8 (higher degree) (19)

- [ ] Applied Computing level 8 (higher degree) (20)
- [ ] Computing with Language level 8 (higher degree) (21)
- [ ] Computer Science and Language level 8 (higher degree) (22)
- [ ] Computer Science and Business level 8 (higher degree) (23)
- [ ] Computer Games Development level 8 (higher degree) (24)
- [ ] Other (25)

Display This Question:

If Please select all relevant computer science, computer engineering, computing or IT related course... = Other

Q19 Please give details of any other computer science, computer engineering. computing or IT related courses you have applied for

____

End of Block: Block 1

Start of Block: CS outreach and experience

Q20 Have you engaged in any other computer science outreach activities (apart from CodePlus) in the past 2 years? (select all relevant choices)

- [ ] No (1)
- [ ] CoderDojo (2)
- [ ] Library Courses (3)
- [ ] After school or lunchtime clubs (4)
- [ ] Other (5)

Display This Question:

If Have you engaged in any other computer science outreach activities (apart from CodePlus) in the p... = Other

Q21 Please give details of any other outreach activities or programmes you have engaged in the past 2 years.

____

Q22 Do you have a family member, friend or someone you would describe as a role model studying or working in the area of computer science, computer engineering, computing or IT? (select all that are relevant)

- Mother (1)
- Father (2)
- Sister (3)
- Brother (4)
- Aunt (5)
- Uncle (6)
- Female Cousin (7)
- Male Cousin (8)
- Male Friend (9)
- Female Friend (10)
- Male Teacher (11)
- Female Teacher (12)
- Other (13)

Display This Question:

If Do you have a family member, friend or someone you would describe as a role model studying or wor... = Other

Q23 If other selected please give details of your relationship to this person

____

Q24 To what extent would you say you have received positive encouragement to study a computing related course from the following people?

	No postive encouragement (1)	A little postive encouragment (2)	Reasonable positive encouragement (6)	A lot of positive encouragement (5)
My family (1)	○	○	○	○
My friends (2)	○	○	○	○
A teacher or teachers (3)	○	○	○	○
Other(s) (4)	○	○	○	○

Display This Question:

If To what extent would you say you have received positive encouragement to study a computing relate... [Other(s)] (Recode) Is Not Empty

Q25 If you selected other(s) please specify your relationship to the person/people

____

Q26 At the time you began 5th year, was Computer Science offered as a leaving certificate subject in your school?

○ Yes (1)

○ No (2)

○ I'm not sure (3)

Display This Question:

If At the time you began 5th year, was Computer Science offered as a leaving certificate subject in... = Yes

Q27 Did you take Computer Science as a leaving certificate subject?

- Yes (1)
- No (2)
- Yes but I dropped out of the class before the leaving certificate examinations (3)

Display This Question:

If At the time you began 5th year, was Computer Science offered as a leaving certificate subject in... = No

Or At the time you began 5th year, was Computer Science offered as a leaving certificate subject in... = I'm not sure

Q28 Would you have taken Computer Science as a leaving certificate subject if you could have?

- Yes (1)
- No (2)
- I'm not sure (3)

End of Block: CS outreach and experience

Start of Block: CodePlus Workshops

Q29 Please select all workshops that you have attended with CodePlus/Bridge21

- CodePlus introductory week (1)
- CodePlus advanced week (2)
- Invent Week (3)

Q30 In terms of helping you to decide whether or not you would be interested in studying a computer science, computing or IT related course, how valuable were the following aspects of the CodePlus workshops?

	Very valuable (1)	Valuable (2)	Somewhat valuable (3)	Had no value (4)	I'm not sure (5)
Learning in an all-female environment (1)	○	○	○	○	○
Learning in teams (2)	○	○	○	○	○
Activities and projects related to real-world problems (3)	○	○	○	○	○
The mentors/helpers (4)	○	○	○	○	○
Understanding more about careers in computer science and computing (5)	○	○	○	○	○
Receiving encouragement to explore careers and study in the area of computing (7)	○	○	○	○	○
Spending time on the Trinity College campus (6)	○	○	○	○	○

Q31 To what level would you agree with the following statements...

	Strongly agree (1)	Agree (2)	Neither agree nor disagree (3)	Disagree (4)	Strongly disagree (5)
I have had enough experience with computer science, coding, and programming to make an informed decision as to whether or not I would like to study a related third level course (1)	○	○	○	○	○
My experience with the CodePlus workshops helped me to make an informed decision as to whether or not I would like to study a related third level course (2)	○	○	○	○	○

My experience with the CodePlus career talks helped me to make an informed decision as to whether or not I would like to study a related third level course (3)	○	○	○	○	○

End of Block: CodePlus Workshops

Start of Block: CodePlus Talks

Q32 Did you attend a career talk from a woman or women working in the tech industry either in your school, in Trinity College or during a company visit in the past two years (tick all that apply)

- ▢ In school talk (1)
- ▢ Company talk (2)
- ▢ In college talk (3)
- ▢ No (4)

Display This Question:

If Did you attend a career talk from a woman or women working in the tech industry either in your sc... != No

Q33 In terms of helping you to decide whether or not you would be interested in studying a computer science, computing or IT related course, how valuable were the following aspects of the career talks?

	Very valuable (1)	Valuable (2)	Somewhat valuable (3)	Had no value (4)	I'm not sure (5)
Getting to meet a female role model in the industry (1)	○	○	○	○	○
Understanding more about careers in computer science and computing (2)	○	○	○	○	○
Learning about the variety of jobs in the industry (3)	○	○	○	○	○
Learning about the advantages of working in the industry (4)	○	○	○	○	○
Visiting a tech company (5)	○	○	○	○	○

End of Block: CodePlus Talks

Start of Block: Block 8

Q34 Please select an option below

- ◯ Submit survey (1)
- ◯ Do not submit survey (2)

End of Block: Block 8

10.5 Appendix E: Qualitative Reflection Questionnaire

Name

School ____

Team Name ____

1. Overall, how would you rate your experience at the CodePlus programme?

Excellent	Good	Average	Fair	Poor
☐	☐	☐	☐	☐

Why do you feel this way?

____

____

____

____

2. Would you be interested in participating in other Coding workshops with this project during the year?

Yes	No
☐	☐

Please explain your decision…

____

____

____

____

3. **Three** things I learned about **myself** and **how I learn** during the programme…

1.   2.   3.

4. Any other comments or suggestions to improve the programme?

____
____
____
____
____
____
____
____
____
____
____
____

Thanks! ☺

10.6 Appendix F: Consent Forms

Participant Information Sheet

Your school has agreed to participate in the CodePlus research project. A collaboration between the the School of Computer Science & Statistics and the Trinity Access programme in Trinity College Dublin. The principal investigator is Grace Lawlor supervised by Professor Brendan Tangney.

The overall aim of the programme is to provide a learning experience for young female students to explore potential careers related to computer science through the use of technology and teamwork. The programme seeks to positively engage students and encourage them to raise their personal learning aspirations. This research involves collecting both short and long term data to evaluate the impact of the programme which is explained in more detail below.

During the programme you will be involved in different innovative learning experiences and researchers from Trinity College would like to collect information about your views on those experiences. You can choose whether or not you would like to participate in this research, which could involve the following: Interactions between you and your classmates working together may be observed and recorded; interactions between you and your teacher may be recorded; you may be asked to complete questionnaires and feedback forms at different times during the programme; you may also be selected to take part in an interview either individually, or with a small group of your classmates, which will last between 20 and 30 minutes. The project seeks to examine long term impact so we are asking for participants and their parents to give their permission to be contacted in the future (approximately 2 years following participation in the programme).

All information that is collected by the researchers will be anonymised (all names will be removed) and stored in Trinity College, Dublin. For the questionnaires and grade information, each student will be allocated a unique identification number, which will permit the researchers to look at changes over time, but will not be able to be used to identify any student by name. In the unlikely event that information about illegal activities should emerge during the study, the researchers will have to inform the relevant authorities. The results of the research are likely to be used in lectures, Ph.D. theses, conference presentations and journal articles, but you or your school will not be identified.

Your participation in the research aspect of the programme is voluntary and you can change your mind about it at any time – in that case we will not use any information already collected about you, but you can continue to be involved with any of the CodePlus activities that are offered to your school.

From time to time, we may also record video footage and images of you, your classmates and your teachers at work, which might be used in communications and promotional/marketing material about the CodePlus project, or in dissemination activities such as conference presentations. You have the right to be anonymous; therefore your name will not appear alongside any images/video footage. Please keep in mind that you can change your mind at any time about the use of your image, and in that case we will not use any images/video footage associated with you.

If you have any questions, please do not hesitate to ask your teacher, or programme coordinator Grace Lawlor grace@bridge21.ie.

Yours sincerely,
Grace Lawlor

Project Coordinator CodePlus

CodePlus Participant Consent Form

I, ____(your name) have read the information sheet provided about the project and know how information will be collected and stored. I understand that I can choose not to take part in the research at any time.

Please sign below to indicate your consent

Data collection for **research purposes**

1. I consent to participating in the research associated with the CodePlus research project. I am aware that this may involve filling in **questionnaires** and participating in individual or group **interviews**. I agree to Trinity College, University of Dublin storing any personal data relating to me that results from this project. I agree to the processing of such data for any purposes connected with the research project as outlined to me.

Signature of participant: ____

Images/Video

2. I consent to images/video footage of me being occasionally used for promotional material about the CodePlus project, or in dissemination activities such as conference presentations, and understand that I will not be identified by name.

Signature of participant: ____

Date: ______________________

Signature of Project Leader (TCD): ____

Date: ______________________

Parent/Guardian Information Sheet

September 2019

Dear Parent/Guardian,
Your school is participating in a research project called CodePlus This project is a collaboration between the School of Computer Science & Statistics in Trinity College Dublin and the Trinity Access programme. The principal investigator is Grace Lawlor, supervised by Professor Brendan Tangney.

What is it?

The overall aim of the programme is to provide a learning experience for young female students to explore potential careers related to computer science through the use of technology and teamwork. The programme seeks to positively engage students and encourage them to raise their personal learning aspirations.

What does it involve?

The project will take place during school time throughout the school year and will be a mix of coding workshops and career talks from women working in the technology sector.
These activities will take place either in school, Trinity College or in a number of technology companies (talks). Students will be under the supervision and guidance of adults at all times. All activities will comply with best practice in Child Protection and the policies of Trinity College in this area, as well as any relevant school policies, to ensure that students benefit from the learning opportunities in a safe and effective manner.
All staff have undergone the Garda Vetting procedures to receive clearance to work with minors. In the unlikely event that information about illegal activities should emerge during the study, the researchers will follow the school's Child Protection policy and inform the relevant authorities.

Research

In order to investigate the effectiveness of the project, researchers from Trinity College will collect information about the students' learning experiences, their attitudes and aspirations, and their educational and family background. Students may be asked to complete questionnaires, feedback forms or reflections at various intervals during the project, and a sample of students will be asked to participate in interviews and focus group discussions, of no more than 30 minutes' duration. The project seeks to examine long term impact so we are asking for participants and their parents to give their permission to be contacted in the future (approximately 2 years following participation in the programme).
There may be lectures, Ph.D. theses, conference presentations and peer-reviewed journal articles written as a result of this project, however the students and school will not be identified.

Data Handling

All information that is collected by the researchers will be anonymised and stored in accordance with the General Data Protection Regulation at Trinity College, Dublin. For the questionnaires and grade information, each student will be allocated a unique identification number, which will permit the researchers to track changes in engagement, but will not be able to be used to identify the student by name.

Research Consent

We wish to seek your permission for your child to participate in the research part of the programme. Participation in this part of the programme is voluntary and you may remove your child from the process at any time, for any reason, without penalty and any information already recorded about them will not be used. Should you wish your child to be omitted from the research aspect of the project, they will still participate in the programme, but none of their information will be used in the research. Full information about your data protection rights are available on this website: https://ec.europa.eu/info/law/law-topic/data-protection/reform/rights-citizens_en.

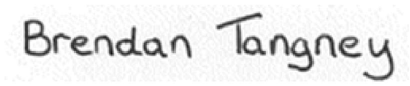
Images

From time to time, we may also record images and/or video of your child and their classmates and, which might be used in communications and promotional/marketing material about the **CodePlus** programme, or in dissemination activities such as conference presentations. Use of video footage and images will be strictly in accordance with best practice in Child Protection policies and guidelines. Your child's name will not appear alongside any images/video footage.

Consent is being sought for the use of any individual/small group photos that include your child. Should you wish your child to be omitted from such material, they will still participate in the programme, but no images/video footage of them will be used in any dissemination, marketing or promotional materials. Crowd-based photos may be taken on the basis of public interest, without prior consent. Parents or data subjects can object to the use of images in crowd-based photos at any point in the future, by contacting us at the email address below.

Please sign below to indicate your consent and return the form to the School Principal's Office as soon as possible. If you have any questions in relation to this, please do not hesitate to contact us.

Yours sincerely,



Brendan Tangney, B.Sc., M.Sc., Ph.D., F.T.C.D.
Professor in Computer Science
Supervisor
E: tangney@tcd.ie

Grace Lawlor

CodePlus Research Coordinator

Principal Investigator

T: +

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CodePlus Parent/Guardian Consent Form

I ____________________________________ (*name of parent/guardian*) have been provided with an information letter that outlines the activities that _______________________________ (*name of child*) will take part in, how research data will be collected and stored and how I can contact the research team. I understand that I may withdraw my child from the research project at any time should I wish to do so for any reason and without penalty.

Please sign below to indicate your consent

Data collection for **research purposes**

1. I consent to my child participating in the research associated with to the CodePlus project. I am aware that this may involve my child filling in **questionnaires**, participating in individual and/or group **interviews**.. I agree to Trinity College, University of Dublin storing any personal data relating to my child that results from this project. I agree to the processing of such data for purposes associated with the research project as outlined to me.

Signature of parent/guardian: ____

Images/Video

2. I consent to individual or small group images/video footage of my child being occasionally used for promotional material about the CodePlus project, or in dissemination activities such as conference presentations, and understand that they will not be identified by name.

Signature of parent/guardian: ____

Date: ______________________