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Parental Involvement in Computer Science Education and Computing Attitudes and Behaviours in the Home: Model and Scale Development

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This work is situated in research on Parental Involvement (PI) in Computer Science (CS) Education. While the importance of PI in children's education is well established, most parents have little experience in CS and struggle to facilitate the learning of a child in the area. If PI in CS Education is to happen, then we argue that parents need support and that understanding the current behaviours and attitudes toward CS in the family context is important to discerning the form that support should take. This article therefore describes the development of an instrument to identify factors relating to parental attitudes toward and motivation for PI in CS education. Relevant variables situated in the context of parental computing behaviours and attitudes in the home were identified using a literature review and expert focus group. These include computing usage, availability, confidence, and experience. To measure these variables, a survey instrument was developed and administered to a large sample of parents (n = 1228). Results of exploratory and confirmatory factor analysis confirm that the instrument measures five constructs, namely "Confidence," measuring parental confidence levels with computing; "Attitude to PI"; "Motivation for PI"; and two types of "Usage": Creation and Consumption. Results of Pearson correlation revealed significant positive relationships between confidence and both positive attitudes toward, and motivation for, PI, with linear regressions confirming that confidence was a significant predictor of both. Regression analysis also identified that creative usage was a predictor of positive attitudes to PI, and that programming experience was a predictor of attitude to, and motivation for, PI. These findings were further validated through triangulation with qualitative data from focus groups with the target population. We conclude that this understanding of the predictors of PI attitudes and motivation should inform the design of initiatives to address parental engagement in CS Education.

CCS Concepts: • **Social and professional topics** → **Professional topics**; **Computing education**; **K-12 education**; **Computing education programs**; **Computer science education**; **Adult education**;

Additional Key Words and Phrases: Parental involvement, model development, computer science education

This research is funded by Science Foundation Ireland's Discover Programme and administered by the School of Computer Science and Statistics, Trinity College Dublin with the support of the National Parents Council (Primary). Workshops have been supported by Microsoft Ireland.

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1946-6226/2021/05-ART18 $15.00
https://doi.org/10.1145/3440890

ACM Reference format:
Nina Bresnihan, Aibhín Bray, Lorraine Fisher, Glenn Strong, Richard Millwood, and Brendan Tangney. 2021. Parental Involvement in Computer Science Education and Computing Attitudes and Behaviours in the Home: Model and Scale Development. *ACM Trans. Comput. Educ.* 21, 3, Article 18 (May 2021), 24 pages.
https://doi.org/10.1145/3440890

1 INTRODUCTION

The teaching of Computer Science (CS) at the K12 level has increasingly become part of the national educational policy in many countries [34]. This has been driven by a worldwide skills shortage in the technology sector but has also been rationalised by the broader argument of the general value and applicability of Computational Thinking as a problem-solving skill [60, 63]. International studies have shown that parents place a high value on science, technology, engineering and mathematics (STEM) Education [42] and strongly support the inclusion of CS into the school curriculum [21, 22]. Equally, the benefits of Parental Involvement (PI) in children's education have been widely acknowledged [5, 16, 17, 24, 45].

However, there is a concern that the current generation of parents do not have the educational experiences or resources to foster their children's motivation and learning in the area of CS. In addition, while the issue of PI has been extensively studied, the issue of PI in CS education has not been adequately addressed; previous studies in the area tend to look at the positive impact of PI on children rather than at the factors that have an impact on its nature and quality [2]. We argue, therefore, that interventions designed to address these issues should be informed by an understanding of the parental attitudes and behaviours that have an impact on the quantity and quality of PI in CS Education. As such, the aim of this study is to (a) identify parents' own computing attitudes and behaviours that are related to PI in CS education, with a particular focus on which of these may predict how and why certain parents become involved, and (b) to develop and validate a corresponding research instrument that can be used to measure these constructs.

1.1 Background and Context

1.1.1 CS Education in Ireland. The Irish school system is made up of primary and second-level education. Primary education consists of an eight-year cycle: junior infants, senior infants, and first to sixth classes commencing at age four or five. Pupils normally transfer to second-level education at the age of 12 or 13. Second-level is split into a 3-year Junior Cycle and a 2-year Senior cycle with an optional 'Transition Year' in between. It culminates in the state terminal examination known as the Leaving Certificate. Until recently there has been little in the way of formal provision of CS as a subject in Irish schools. However, recent developments include an optional Junior Cycle Short Course in Coding and the introduction, in 2018, of Computer Science as a Leaving Certificate subject. This is being rolled out on a phased basis starting with a group of 40 schools in September 2018 with a national roll-out to all schools from September 2020. There is, as yet, no formal provision of CS in the national primary curriculum. However, the National Council for Curriculum and Assessment[1] "Coding in Primary Schools" Initiative is currently looking at ways of introducing it and have developed a physical computing and play-based pedagogical approach to coding and computational thinking that was piloted across 25 schools in 2018 and 2019 [44].

1.1.2 Parental Involvement in Education. The OECD defines PI as "parents' active commitment to spend time to assist in the academic and general development of their children" [5, 13]. The

[1]The NCCA advises the Irish Minister for Education and Skills on national curriculum and assessment for early childhood education, primary and post-primary schools and assessment procedures used in schools and examinations on subjects that are part of the curriculum.

role of parents in their children's education has long been of interest to researchers, educators and policy makers. However, investigating the impact of PI is inevitably complex due to the interaction and influence of many factors and variables. Despite this complexity, findings consistently provide evidence that PI is strongly associated with higher cognitive and non-cognitive outcomes [5, 16, 17, 24, 45]. Moreover, there is evidence that specific interventions to improve PI can have a positive effect on reading, writing, and mathematics skills [19, 33, 52]; homework completion [10]; and behaviour [36, 46]. This is despite the complexities involved in the design of such interventions, including delivery, uptake, and sustainability [24]. The OECD therefore argue that promoting higher levels of PI may increase student outcomes and that high-quality PI may help reduce performance differences across socio-economic groups [5]. The importance of this happening at an early stage of children's schooling to maximise its impact is emphasised in Sylva et al.'s review of early childhood literature [53].

PI is generally categorised as formal or school-based PI and informal or home-based PI [5, 25, 29]. School-based PI tends to include structured activities such as attending parent-teacher meetings and volunteering in school. Home-based involvement, in contrast, may be less structured and can be further split into academically oriented and non-academic [37]. The relative impact of each type of PI is disputed with Harris and Goodall concluding that parental engagement in children's learning in the home makes the greatest difference to student achievement: "Most schools are involving parents in school-based activities in a variety of ways but the evidence shows but this has little, if any, impact on subsequent learning and achievement of young people" ([25], p. 277). In contrast, Pomerantz et al. point to consistently positive associations between school-based PI and student outcomes but less consistent results about home-based involvement [47]. Borgonovi and Montt [5] suggest that this may be a symptom of the unstructured nature of home-based involvement, which leads to a huge variation in its quality. This leads to a conclusion that any consideration of how to maximise the benefits of home-based parental involvement necessitates a close examination of its nature and quality or what Pomerantz et al. [47] characterise as the "how, whom, and why" of parents' involvement.

1.1.3 Parental Involvement and Computer Science Education. Research into family computing use has tended to look at broader Information and Communications Technology (ICT) issues and focus on concerns such as internet safety and digital literacy with the attention on parents managing and mediating children's internet use [23, 39]. While some studies have found a positive relationship between pupils' ICT competences and the support they receive at home [2, 57], computing in the home tends to be viewed as a passive or consuming activity rather than something that is active or creative. In this context, children's computing use is often perceived as a contentious issue that needs to be carefully regulated and controlled by parents [11].

The resurgence of CS as a subject at K12 level has led to questions over the capacity of parents to support their children's learning in this area [35, 48]. Many parents' own education has left them with little experience in programming or computational thinking with the result that they can experience anxiety, lack of confidence, and gendered assumptions about technology [42]. They therefore struggle to facilitate the learning experiences of a child who has an interest in CS. Despite this, there is strong evidence that parents are interested in supporting CS Education: Ninety-one percent of US parents want their children to learn more CS and two-thirds think CS should be required learning in schools [22]. This desire for CS education among parents, and their willingness to support it, is also evident in Ireland with two in three believing it to be as important as mainstream subjects despite a current lack of availability in schools [21] and 95% believing that it should be taught in primary schools [8]. Parents are also key to choosing non-formal activities [14], and their willingness to support CS education for their children is also clearly demonstrated by the huge success of non-formal coding clubs. The CoderDojo movement[2] was founded in Ireland in 2011 and there are currently over 250 Dojos nationally and over 2,000 internationally where parents are required to accompany their children and, indeed, often set up and run the dojos. Code Club[3] has over 13,000 clubs internationally, and, while these are generally run in schools by teachers, they are often supported by parent volunteers. Parents' influence on their children's educational choices in this area is also crucial; with parental support found to be significantly associated with general "career decidedness and career self-efficacy" [12]. However, while 73% of Irish parents recognise themselves as the biggest influencers of subject choice, 68% reported feeling "moderately," "poorly," or "very poorly" informed on STEM career opportunities and industry needs [1]. As the formal provision of CS Education at all levels grows, parents' capacity to support their children will become increasingly important.

Despite concerns over the capability of parents to engage in CS education, there is some evidence to suggest that they can directly influence learning when they choose to engage in coactivity with their children [49, 54]. In addition, Maruyama [40] found attitudes toward and confidence in supporting children at home improved as a result of participation in a parent–children workshop. However, our review of related research revealed little in the way of specific programmes to capitalise on this, with some notable exceptions such as MIT's Family Creative Learning programme [48] and Brahms exploration of family participation in a museum-based maker space [7]. Clarke-Midura et al. [12] encouraged child participants of a coding camp to bring their creations home and share them with their families, arguing that building this feature into their curriculum design may have influenced participants' perceptions of parental support. However, it seems that opportunities to actively engage in computing activities are usually directed toward either children or adults rather than families engaging in co-learning experiences [48].

1.2 Research Aims and Scope

Despite the acknowledged importance of parental involvement for children's learning, an extensive review of the literature found no studies directly exploring the factors that affect parental engagement in CS education. **The aim** of this research is therefore to address this by examining the relationship between parents' own computing attitudes and behaviours and their attitudes toward PI in CS education through the following:

- the identification of factors relating to parental attitudes toward PI in CS education;
- the development and validation of a corresponding research instrument to measure these factors.

The purpose of developing this instrument is to guide future empirical research into the design of PI strategies by providing a greater understanding of the factors that affect PI in CS education. It also aims to provide a validated instrument for the evaluation of any such strategies.

The research described in this article forms part of a larger exploratory study into the level and form of assistance parents require to better support their children in their CS education [8]. As previously noted, the factors impacting on the nature and quality of PI are complex and operate on many levels. For example, parents' socio-economic status, cultural background, gender, and education levels are all significant [16]. Epstein's influential model emphasises the shared responsibilities of schools, families, and communities [18], and Hornby and Lafeale identify individual parent and family factors, child factors, parent–teacher factors, and societal factors [30]. While acknowledging this complexity, the scope of this article is focused on understanding how parents'

[2]https://coderdojo.com/.
[3]https://codeclub.org/en/about.

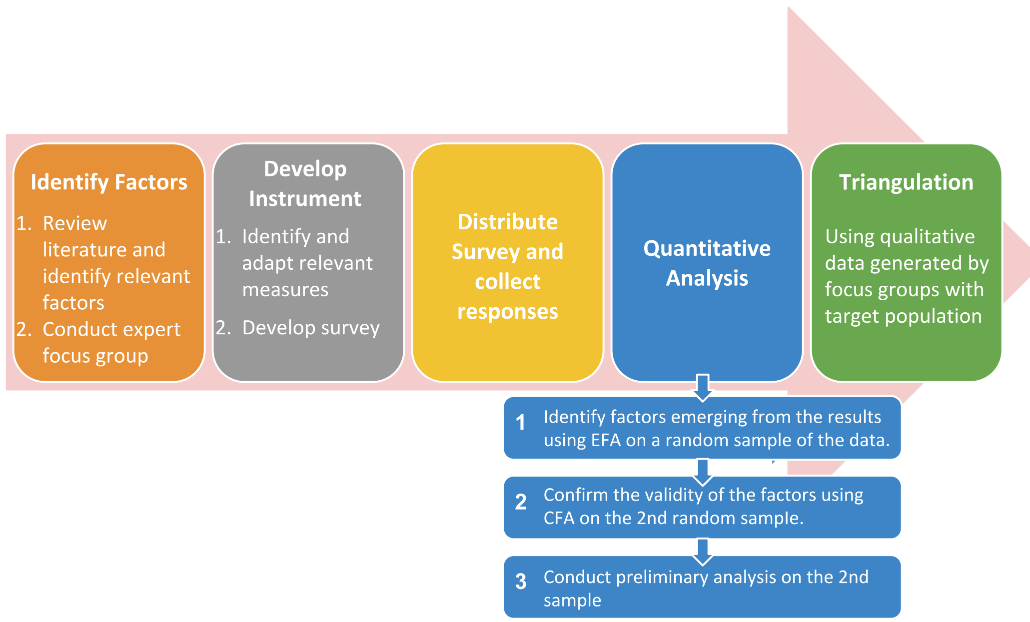

Fig. 1. Research design steps.

computing attitudes and behaviours in the home can impact on attitudes to and motivation for PI in CS education.

2 MATERIALS AND METHODS

2.1 Research Design

To address the aims of this research, it was necessary to identify factors that may have an impact on PI attitudes and motivation. This was done by reviewing relevant literature and subsequently conducting a focus group with $n = 5$ domain experts to establish the face validity of the findings. Having established potential factors and a causal hypothesis in this way, we again looked to the literature to identify existing measures that could potentially be modified to fit the concepts that we were looking to address. It was then necessary to develop a survey using the adapted measures and to distribute it through various channels, using voluntary response sampling techniques. Once the responses were collected, a cross-validation process was used to identify and then confirm the emerging factors. Identification of the factors emerging from the data was completed using exploratory factor analysis (EFA) on a random sample of the data, with confirmatory factor analysis (CFA) used to confirm the findings on the remaining data. Preliminary analysis was conducted on the second sample of the data, which had not been used for EFA. Finally, our findings were triangulated using qualitative data from three focus groups conducted with the target population. What follows explores each of these steps (Figure 1) in more detail.

2.2 Identification of Factors

2.2.1 Literature Review. A literature review was conducted in an effort to identify relevant factors in the context of PI in CS education. A preliminary search revealed that the issue of PI in this context has not been adequately addressed. Indeed, McGill et al.'s [43] Gap Analysis of non-cognitive constructs in evaluation instruments designed for CS education found that the majority

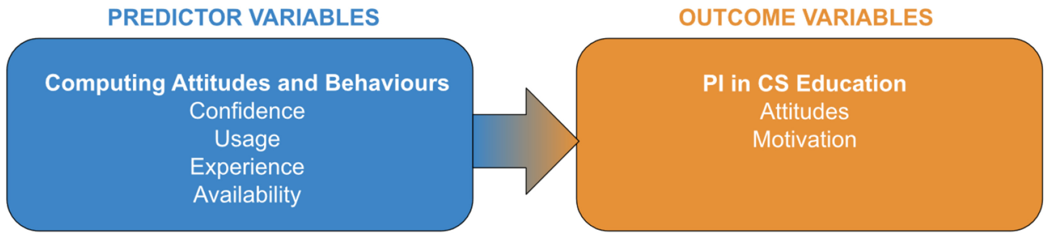

Fig. 2. Causal hypothesis.

of constructs were designed to measure Student Engagement and School Climate. Constructs measuring Social-Familial Influences occur the least, with only 4 of the 132 unique constructs classified as PI constructs [43]. It was therefore necessary to consult analogous research and widen the search to include more general technology, and look beyond parents to include learners and teachers.

Previous studies concerned with factors that affect ICT competencies are, in the main, concerned with general technology skills rather than CS. They also tend to focus on teachers [4] or learners [2, 6, 23, 57, 58, 61, 64, 66] rather than parents [35]. In addition, when PI in CS Education is considered, research is generally focused on its effect on learners rather than on the factors that impact on its nature and quality. For example, the extensive digital competence (EDC) model [2] does identify parental ICT support, parental ICT attitude, and ICT availability in the home as factors in developing ICT competencies in children but does not explore any possible relationship between these factors.

However, these studies do reveal factors that have an effect on teacher technology integration and its role in children's ICT competencies. Aesaert et al. [2] reveal teachers' self-reported ICT competence as a factor that is positively related to their students' ICT self-efficacy and that teachers' negative attitude toward ICT is a barrier toward the integration of ICT. Vannatta and Bannister [56] also identify a number of factors for technology integration in the classroom that can be adapted to apply to the home context:

1. risk-taking behaviours and comfort with technology;
2. perceived benefits of using technology;
3. beliefs and behaviours about technology use;
4. technology use;
5. facilitation of student technology use; and
6. support for technology use and access to technology.

Similarly, Bingimlas's meta-analysis of barriers to integrating ICT in schools identified confidence, competence, and accessibility as the critical components of technology integration in schools [4].

A synthesis of these related studies (Table 1) identified *confidence, usage, experience,* and *availability* as computing-related factors that could be operationalised to examine the relationship between parental computing attitudes and behaviours in the family context and parental attitudes toward and motivation for PI in CS education (note: while the cited literature explored additional factors they are outside the scope of computing attitudes and behaviours in the home). The literature also supported the causal hypothesis that an increase in these factors may have a positive impact on PI (Figure 2).

2.2.2 Expert Focus Group. Consultation with experts or members of the target population using the focus group methodology can be an effective way of informing the initial identification and

Table 1. Identification of Potential Predictor factors Using Analogous Literature

Literature	Confidence	Usage	Experience	Availability
Aesaert et al. (2015)	ICT attitude	ICT use	ICT experience	ICT availability
Binglimas (2009)	confidence		competence	accessibility
Goh et al. (2015)	confidence; attitude	ICT use	ICT competency	home ICT access
Van Brak (2004)	computer confidence	intensity of computer use	computer experience expressed in time	home access to a computer
Vannatta and Banister (2008)	risk-taking behaviors; comfort with technology	technology use	technology competency	support for technology use; access to technology.
Vekiri and Chronaki (2008)		frequency of use; type of activity		access
Vekiri (2010)			IS instruction	
Wang et al. (2015)		frequency of use; activity variety		home computer access
Wong et al. (2015)	self-efficacy		exposure to field; opportunities to program	
Zhong (2011)		ICT usage		school ICT access; home ICT access

specification of key constructs [26, 59]. To this end, a qualitative study using an in-depth face-to-face focus group was undertaken, with a purposive panel of domain experts, to establish face validity for both the factors and the causal hypothesis identified. The proposition that qualitative methods can be used for suggesting causal hypotheses or providing supporting data for "causal" quantitative research is widely accepted (e.g., by Towne and Shavelson [55]). Maxwell [41] goes further and argues that qualitative methods can be used to identify causal relationships. His realist approach argues that adequate causal explanations in the social sciences depend on the in-depth understanding that qualitative research can provide.

Purposive sampling was undertaken and domain expert participants ($n = 5$) including teachers, academics, and coding club mentors (all also parents) were gathered for in-depth discussion of the findings of the literature review and to share their expertise. The researchers adapted eleven constructs exploring inhibitors to parents using technology with primary age children [23] into corresponding focus group questions to guide the discussion. The focus groups were audio recorded, and written observation notes taken, with responses consolidated into transcripts for analysis.

The researchers followed the analytical process described by Campbell et al. [9], which recommends using three stages and two researchers to code and theme text into a model. The first step in the process was predominantly deductive and involved developing a coding scheme informed by the literature review (although this was left open to evolve through reading text responses); the second step involved generating and assigning codes to text that were evaluated through intercoder agreement; and the third step involved clustering codes into sub-themes and themes that were peer reviewed and validated by two coders. The clustering generated $n = 18$ sub-themes, and $n = 4$ themes and continued to fit the conceptual orientation developed from the literature, mapping to the four identified predictor factors. Each of the factors are discussed in turn below, with quotes from a transcript included to add context.

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

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

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

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

2.2.3 Summary. The literature review identified *confidence, usage, experience*, and *availability* as relevant factors situated in the home-computing context. The focus group confirmed that these findings were consistent with their expert experiences and provided verification that the factors identified were potentially ones that would impact on PI attitudes and motivation. The Qualitative data were also used "to both enrich and extend" our knowledge of these factors and "inform item development" [59]. The literature reviewed also provided instruments that could be adapted for use in this context. The following section outlines the development of a survey instrument to measure these factors.

2.3 Instrument Development

The original survey included 19 items that aimed to investigate: parents' computing *confidence* (nine items); *usage* (three items); *experience* (three items); and *availability* (four items). It also

Table 2. Item Development

Variable Type	Factors	Overview	Scales Adapted
	Non-computing/ Demographics	Gender, Age, County, Main Role, Occupation, No. of children in Primary School, their ages and genders	Generic Markers used across instruments designed by our Research Centre.
Predictor Variables (Computing behaviours and attitudes)	Confidence	Ease and enjoyment of computer use	Cutts et al. [15]; Vannatta and Banister [56]
	Usage	Time, task, purpose	Hayward et al. [27]
	Experience	Qualifications, Programming experience	Cutts et al. [15]
	Availability	Devices, Internet access,	Hayward et al. [27]
Outcome Variables	Attitude toward PI in CS Education	How do parents feel about getting involved with their children's CS activities?	Aesaert et al. [2] Vannatta and Banister [56]
	Motivation for PI in CS Education	Why do they want to get involved with their child's CS activities?	Aesaert et al. [2]

contained 10 items relating to the outcome variables: *attitudes toward PI* in CS education (seven items) and *motivation for PI* in CS education (three items). In addition, the survey included seven items that request demographic information. The items were presented in mixed order.

Where possible, items for scales were adapted from existing, validated instruments (Table 2). While, as previously mentioned, the issue of PI in CS education has not been adequately addressed, the previous instruments that engaged with children's and teachers' attitudes and behaviours were examined for comparable scales as described for each factor below. The findings from the expert focus groups further informed the adaptations.

Following the process of exploratory and confirmatory factor analysis described in Section 2.5, some of the original items were combined or split to form a reliable and valid instrument to measure the following seven factors: parental computing confidence and experience, usage of technology for creation and consumption, availability of technology, attitude to and motivation for PI in CS education. The final, 24-item, validated instrument (Parental Involvement in Computer Science (PICS) Survey Instrument) can be viewed in Appendix A.

2.3.1 Predictor Variables (Computing Attitudes and Behaviours).

Confidence. Items that measure parental computing confidence were adapted from those relating to teachers' risk-taking behaviours and comfort with technology in the Teacher Technology Integration Survey [56] and those looking at the link between early childhood experiences and later confidence in computing in Cutts et al. [15]. Participants were asked to rate their level of agreement from *strongly disagree* to *strongly agree*, on a 5-point Likert-type scale with statements such as "learning new things on the computer is confusing for me" and "I feel comfortable about my ability to work with computers."

Usage. Items concerning computing usage were adapted and updated from English DfES surveys on ICT usage directed at young people [27]. These looked at usage patterns (time and purpose). Of particular interest to us, given our research focus on CS rather than digital literacy or general ICT skills, was the nature of the tasks undertaken by parents. Respondents were asked to select the activities for which they used their devices in the home. Following the process of factor analysis outlined in Section 2.5.2, the modes of usage were categorised as creation (website development, programming, etc.) and consumption (internet use, social media, online shopping, etc.). For the purposes of analysis, the creation and consumption factors were calculated by summing associated responses.

Experience. As the context of the study is CS education rather than general ICT skills, this particularly referred to programming experience. This item explored perceived programming competency level [15].

Availability. Items relating to computing availability were also adapted from Hayward et al. [27]. They were designed to gauge access to various devices and adequacy of internet provision. For the purposes of analysis, the overall number of devices and the internet quality in the home were considered as predictor variables.

2.3.2 Outcome Variables (Attitudes toward and Motivation for PI in CS Education).

Attitude toward PI in CS Education. As previously noted, there is very little research that engages directly with this construct. Since this research project began, Kong et al. [35] published a scale to measure parents' perceptions of programming education in schools. While this is a valuable contribution to understanding the role that parents play in CS education, it differs from the current study in that it focuses on parents' perceptions of programming in the school context, rather than how computing attitudes and behaviours in the home relate to PI.

While no existing scales existed for this factor, Aesaert's development of the EDC model and scale for Primary school pupils' ICT competences was useful; it takes the broader classroom and school context in which pupils are embedded into consideration and includes the impact of parental support [2]. The EDC scale, in conjunction with an exploration of secondary school pupils' value and efficacy beliefs about computers [57], informed the relevant items in our instrument. The items are again rated on a 5-point Likert scale in which participants were asked questions that related to their attitude toward PI in computing, such as "I want to help my child understand what programming does" and "I want my child to have fun when learning about computers."

Motivation for PI in CS Education. The EDC model's parental and teacher ICT attitude scales were also adapted to explore the reasons why parents might wish to get involved in their children's CS education [2].

2.4 Survey Distribution

Previous research has shown that (a) ICT competencies should be taught at an early age [2, 42] and (b) that PI is more effective the earlier it occurs [53]. This study therefore identified the parents of primary school pupils in Ireland as its target population.

The procedure for this study was approved by the institutional Ethics Committee. The questionnaires were distributed online in July and August 2018. This was done through interested parties such as the National Parents Council (Primary), the Computers in Education Society of Ireland and the Irish Department of Rural & Community Development to approximately 10,000 parents of primary school children across Ireland. Participants were requested to take part in the survey and were assured that they could withdraw from the study at any point without penalty. It closed having been completed by 1,228 parents, a response rate of just over 10%.

The majority of respondents were female and in the age range 36–45 years old (Figure 3: Participant Gender and Age Range). Most of the respondents had two (40%) or three (41%) children of primary-school age, with a male to female ratio amongst the children of 54% to 46%. Seventy-one percent of the respondents were in full-time employment, with 21% working in the home. Twenty-one percent of respondents identified as having a computing qualification (79% did not), with 68% reporting never having tried to programme at all.

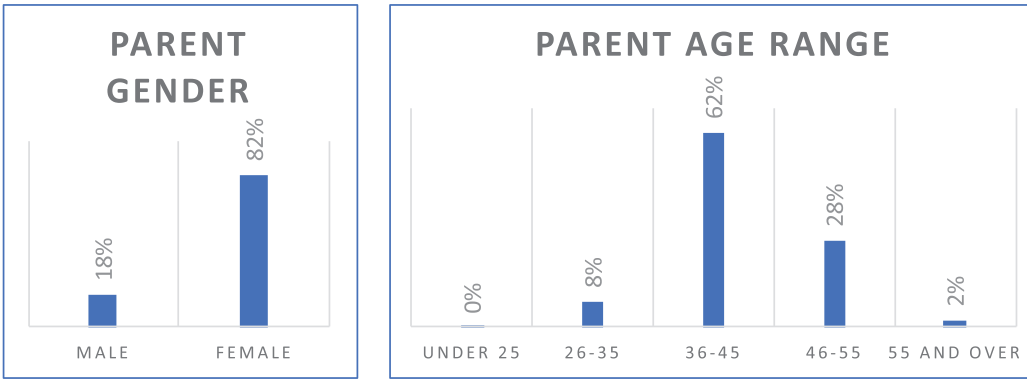

Fig. 3. Participant gender and age range.

2.5 Validity and Reliability

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

Depending on the variable type one of two methods of exploratory factor analysis was conducted. As the *confidence, attitude*, and *motivation* variables scales could be considered continuous, a principal access factoring method, using the statistical software package SPSS 24©, was used for the exploratory factor analysis. A Robust Unweighted Least-squares method conducted using the FACTOR program was used for the dichotomous *usage* scales. Items that measured *experience* and *availability* were not combined into scales and did not therefore require factor analysis. In the factor analysis, coefficients with an absolute value lower than 0.3 were suppressed and not included in the scale development.

Two random samples of approximately equal size were obtained from the data gathered using SPSS. Following analysis of the patterns of missing values in the variables it was shown that there were 572 missing values (3.3% of the data), with no variable having more than 10% missing. Missing values were addressed through a process of multiple imputation [32] and no participants were eliminated from the study at this point.

2.5.1 Confidence, Attitude to PI, and Motivation for PI. To establish the validity of the *confidence, attitude to PI*, and *motivation for PI* factors, an EFA was conducted using SPSS on the first random sample (n = 591). The suitability of the data for factor analysis was confirmed prior to running the tests: The Kayser–Meyer–Olkin measure of sampling adequacy was 0.91, exceeding the recommended minimum value of 0.5, and Bartlett's test of Sphericity was highly significant (<0.001) [20].

The Principal Axis Factoring (PAF) extraction method with Direct Oblimin rotation was used to identify the underlying factor structure of *confidence, attitude to PI*, and *motivation for PI* scales. This extraction method was selected as the data exhibited z-values for skewness outside the recommended levels of ±1.96 for all items. An oblique rotation was utilised as the factors were not expected to be orthogonal [20, 65]. Three factors with eigenvalues greater than 1 were extracted,

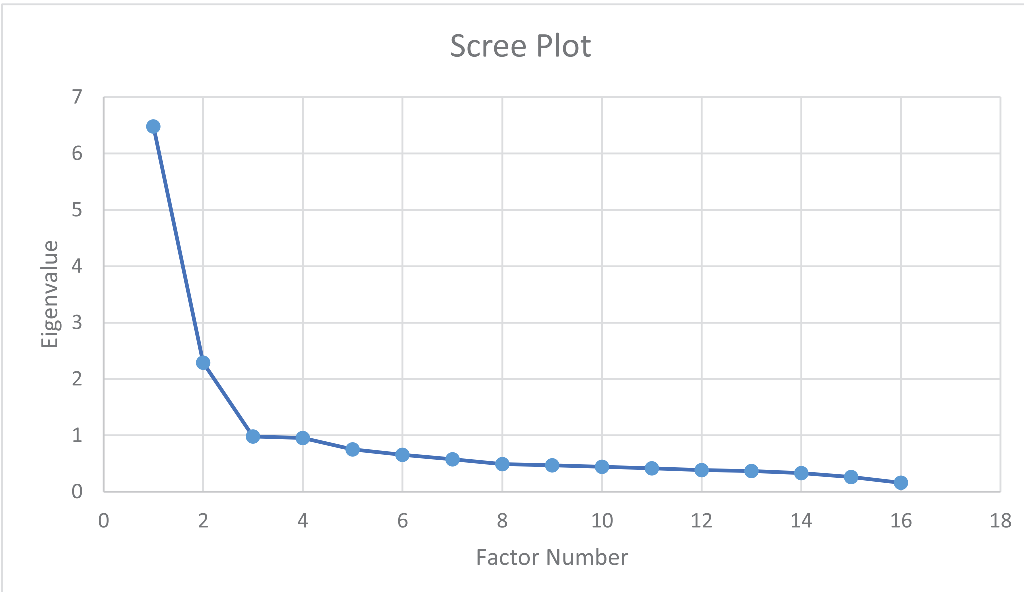

Fig. 4. Scree plot.

explaining 34% and 14% and 4% of the variance, respectively. The number of dimensions was confirmed by the scree plot (Figure 4). The rotated solution (Table 3) explained a total of 51.4% of the variance.

Factor 1 relates to parents' own level of confidence in using technology; factor 2 groups items that relate to attitudes to PI in CS Education; and factor 3 relates to motivation for PI in CS.

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

As the EFA conducted indicated that there were three distinct factors, A CFA, shown in Figure 5, was conducted using SPSS AMOS Graphics software on the second random sample (n = 558). Goodness-of-fit of the model was assessed using a chi-square test, the root-mean-square error of approximation (RMSEA), the Comparative fit index (CFI), and the Tucker–Lewis index (TLI).

The overall fit of the three-factor model was good. Although the chi-squared test was significant, this test is highly sensitive to sample size and skewness and should not serve as the sole basis on which to judge the goodness-of-fit [50]. The CMIN/df = 3.3, and for large sample sizes values less than 5 are deemed reasonable [62], particularly when descriptive goodness-of-fit indices are also considered. Table 4 outlines the values for the descriptive goodness-of-fit indices considered in this study [31, 50, 62].

2.5.2 Usage. To perform EFA on the dichotomous *usage* variable, the FACTOR program[4] was used on the first sample, to conduct Robust Unweighted Least-squares exploratory factor analysis based on tetrachoric/polychoric correlations. This is accepted as being a robust, defensible, and widely used approach for performing item analysis of this kind [3]. CFA was then conducted using SPSS AMOS Graphics software on the second random sample (n = 558) (Figure 6).

[4]http://psico.fcep.urv.es/utilitats/factor/Download.html.

Table 3. Results of PAF for *Confidence, Attitude to PI*, and *Motivation for PI*

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

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 11 iterations.

Table 4. Goodness-of-Fit Evaluation

Fit Measure	Value	Goodness-of-fit
CMIN/df	3.3	Reasonable
RMSEA	0.064	Acceptable
CFI	0.933	Good
TLI	0.914	Good

Goodness-of-fit of the model was assessed using a chi-square test, the RMSEA, the CFI, and the TLI. The overall fit of the two-factor usage model was good, with CMIN/df = 2.88, RMSEA = 0.058, and Standardized RMR = 0.052 [28]. This process identified two factors from the *usage* data that relate to *consumption* and *creation*.

The factor analysis enabled us to identify the underlying structure in the data and confirm that the items used in the questionnaire did indeed measure parental confidence and usage, as well as their attitude to, and motivation for, PI. Inferential analysis was then conducted on the second sample to address the research questions of this study.

3 FINDINGS

To explore possible relationships between the variables in this study and to attempt to identify significant predictors of positive parental attitude to and motivation for involvement in their children's CS education, correlation and regression analyses were conducted.

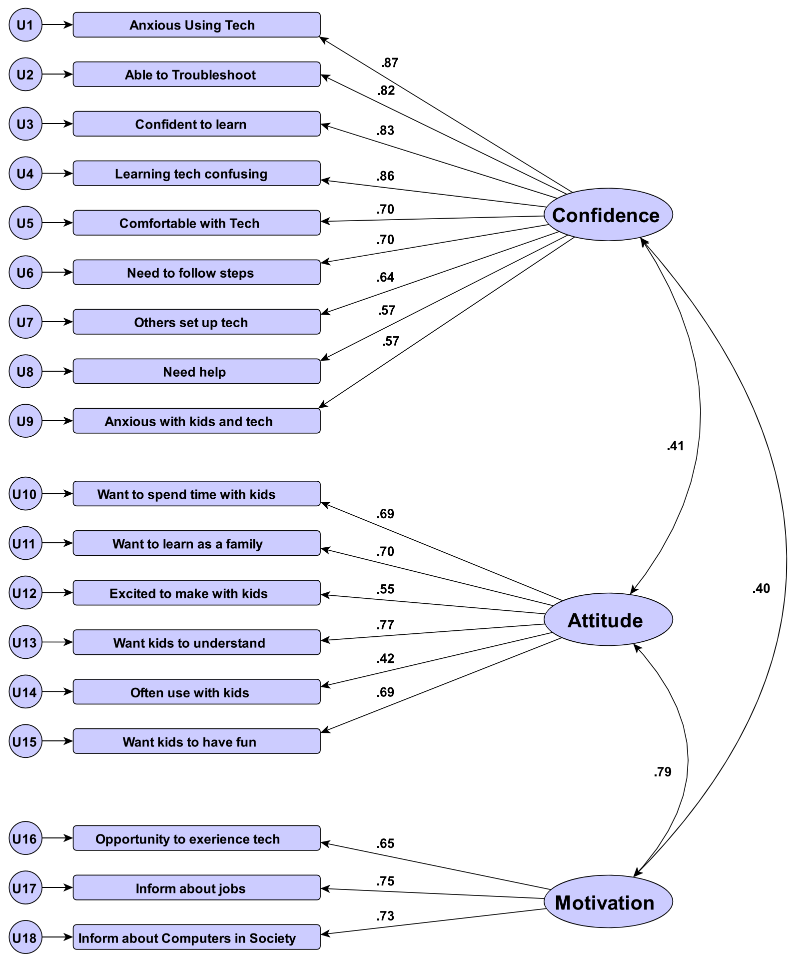

Fig. 5. CFA for the three-factor model of parental computing confidence, attitude to PI, and motivation for PI.

3.1 Correlations

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

Positive correlations were identified between the *attitude to PI* and *confidence* scales ($r = 0.392$, $n = 530$, $p < 0.001$), and the level of *motivation for PI* and *confidence* scales ($r = 0.344$, $n = 519$, $p < 0.001$)

Self-reported programming level (*experience*) and *attitude to PI* ($r = 0.330$, $n = 493$, $p < 0.001$) were also positively correlated, indicating that parents who felt more experienced were more likely to be positively disposed to being involved in their children's CS education. Positive correlations were also identified between *experience* and *motivation for PI*, but to a lesser degree ($r = 0.232$, $n = 488$,

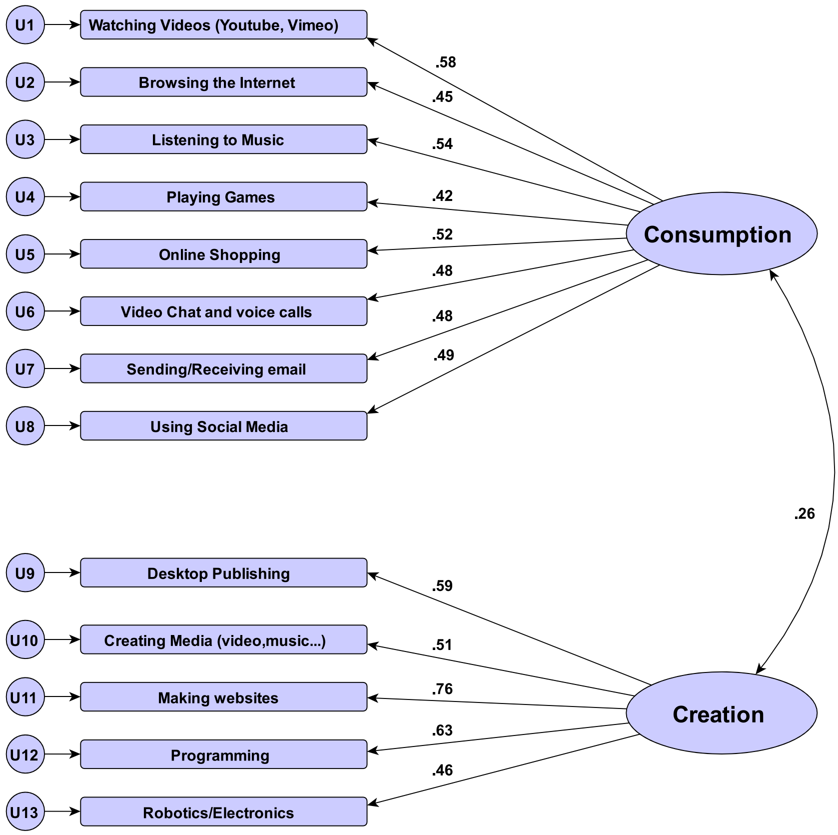

Fig. 6. CFA for the two-factor model for usage in terms of creation and consumption.

$p < 0.001$). Examination of other variables showed that there are positive correlations between numbers of devices in the household (*availability*) and *attitude to PI* ($r = 0.188$, $n = 530$, $p < 0.001$) and *motivation for PI* ($r = 0.178$, $n = 519$, $p < 0.001$) although these relationships are not quite as strong. Internet quality appears to have a small, but statistically significant correlation with *attitude to PI* ($r = 0.176$, $n = 521$, $p < 0.001$). Exploration of the relationships between the types of technology usage in the home and both *attitude to PI* and levels of *confidence*, also revealed significant positive correlations. *Usage* was broken down into the two categories of *consumption* (videos, music, games, social media, etc.) and *creation* (website development, programming, etc.). To be able to establish levels of usage in each of these categories, the scores for each item in the section were summed to provide an overall score. This score ranged from 1 to 5 in *creation* and 1 to 8 for *consumption*, with significant correlations between all of the variables with the exception of *creation* and *motivation for PI*. The strongest correlations were between *attitude to PI* and both *consumption* ($r = 0.191$, $n = 526$, $p < 0.001$) and *creation* ($r = 0.197$, $n = 185$, $p < 0.001$). Similar, if slightly weaker, correlations were also identified between the number of devices in the home, level of programming *experience* and the usage of technology for *consumption*, and *motivation for PI*.

3.2 Linear Regressions

Linear regressions were used to explore whether the variables of *confidence, usage, experience*, and *availability* could be identified as predictors of *attitude to PI* and *motivation for PI*. In particular, the analysis examined which variables were significant predictors of the outcome variables in question, as well as the effect size, or strength of the relationship between the variables. It is important to note that even small effect sizes in educational research can have substantial value at a practical level [13, 38].

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

3.2.1 Confidence as a Predictor. A simple linear regression was calculated to predict *attitude to PI* based on levels of parental computing *confidence*. The analysis indicated that increased levels of *confidence* is a significant predictor of higher levels of *attitude to PI* ($F(1, 528) = 95.894$, $p < 0.001$), with an $f^2 = 0.19$. This can be considered a medium effect size [51] and indicates that participants' attitudes to PI became more positive by 0.285 for each unit increase on the confidence scale (both scales are measured from 1 to 5).

Levels of *confidence* were also identified as a significant predictor of higher levels of *motivation for PI* ($F(1, 517) = 69.217$, $p < 0.001$), with an $f^2 =.133$. This indicates that for each unit increase on the confidence scale, parental levels of motivation increased by 0.265, and this is considered a small effect size [50].

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

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

3.2.3 Experience as a Predictor. Programming experience as a predictor of *attitude to PI* and *motivation for PI* was also explored. In both cases, *experience* was found to be a significant indicator ($F(1, 491) = 60.145$, $p < 0.001$ for attitude; $F(1, 486) = 27.694$, $p < 0.001$ for motivation), with a small effect size ($f^2 = .122$ and $f^2 = .057$ respectively) in each case.

3.2.4 Availability as a Predictor. Finally, to evaluate the impact of computing *availability* on *attitude to PI*, a two-scale model was used for multiple linear regressions. The model consisted of the items relating to the number of devices in the home as well as the quality of the internet; both items were included in the model as both were shown to positively correlate with the attitude variable. Once again, a backwards elimination model was used. The two-scale model was found to be a significant predictor of *attitude to PI* ($F(2, 518) = 18.250$, $p < 0.001$), with a small effect size ($f^2 =.071$).

As internet quality did not correlate significantly with *motivation for PI*, this was not included in the *availability* model for this variable (hence the presence of the "N/A" entries in Table 5). A linear regression indicated that the number of devices in the household is a significant predictor of *motivation for PI* ($F(1, 517) = 16.853$, $p < 0.001$) with a small effect size ($f^2 = .033$).

Table 5. Predictive Power Summary

	PI Attitude	PI Motivation
Parental Confidence	Significant predictor **Medium** effect	Significant predictor **Small** effect
Creative usage of technology	Significant predictor **Small** effect	Not significant predictor
Programming experience	Significant predictor **Small** effect	Significant predictor **Small** effect
Availability of devices and Internet	Significant predictor **Small** effect	N/A
Availability of Devices	N/A	Significant predictor **Small** effect

3.3 Summary

Table 5 summarises the Relationships between the Predictor and Outcome Variables. The results of inferential analysis showed that there is a positive correlation between parents' *confidence* levels and their *attitude to PI*. The level of parental *confidence* was also identified as a significant predictor of higher levels of *motivation for PI*. Perhaps unsurprisingly, it emerged that parents who have previous programming *experience* also had a more positive *attitude toward PI*. When looking at technology use, we found that parents who use technology for creative purposes are more likely to have a positive attitude to involvement in their children's CS education. All of the scales broadly confirmed the factor structures as hypothesized and our findings are generally consistent with the analogous research consulted in the identification of those factors (see Table 1).

4 TRIANGULATION (PARENTAL FOCUS GROUPS)

The quantitative findings from the survey were corroborated through triangulation with the findings of three focus groups. These involved a total purposive sample of $n = 18$ parents of primary school children who were attending three family creative-coding workshops [8]. While the focus groups were designed primarily to discuss their experience of the workshops, as part of this discussion, attitudes toward and motivation for PI in CS Education were explored. Each focus group was audio recorded, with text transcriptions again coded according to Campbell et al. [9], as described in Section 2.2.2. While *availability* did not emerge as a theme (all participants brought their own devices to the workshops suggesting availability was a non-issue for them), *experience, usage*, and *confidence* did, and the discussion provided a richer understanding of the meanings, contexts, and processes involved in these factors.

Lack of confidence emerged strongly as an inhibitor of PI: *"I didn't have any idea of what internet technologies are, a little bit more understanding of their role. . . . I was new to technology."* However, the participants reported a rise in confidence as a result of the workshop and this was reflected in comments such as "*if it doesn't work the first time, you just go back, and try it again*" and *"we figured it out, yeah it was like, you still have to follow your own method,"* as well as *" it was a good case of you weren't going to be unable to do something. It wasn't totally spoon-fed to you either, you know what I mean?"* Participants also reported that they were more likely to engage in similar activities at home: *"I would like to get them more involved, you know? I'd like to push it a bit more I think"*.

There was some evidence that the inter-family collaborative and creative usage of computing during the workshops had changed attitudes to PI. One parent realised that this was an option that could be practiced at home with family members: "*I think we learnt that um, that everyone could work on different things, and be independent in teams, and that we can, do things together, em,* *I think in our house, we will think about how it will work, using different gadgets, and bits, and yeah, it's some, it's another way to bring us together."* Another remarked that *"it's really good to have something concrete at the end, you start, and you work through the tasks, you know, I can see it."*

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

The above examples indicate that if parents gain computing confidence, through working alongside their children on creative and collaborative projects, they report a more positive attitude to and greater motivation for PI in CS. This includes parents with little technology experience, while parents with more experience of technology also expressed satisfaction in the shared activities.

5 DISCUSSION AND CONCLUSIONS

Goodall and Vorhaus's review of best practice in parental engagement emphasises the importance of "understanding what parents already do with their children and how they are most likely to respond positively to attempts to engage them (further) in their children's learning" [24,7]. In the case of CS education, this understanding is currently lacking. Our research has the potential to address this in a number of ways. For practitioners, we envisage it being of practical use in the design of initiatives to address issues of PI. Our findings strongly indicate that increasing parents' computing confidence is likely to have a positive impact on their attitudes toward, and motivation for engagement in their children's CS Education. Other positive predictors for attitude to and motivation for PI are parents' programming experience, computing availability, and usage of technology for creative purposes.

As a result of the understanding gleaned through this research, we propose that any interventions intended to improve the quantity and quality of PI should be designed to increase parents' own confidence, particularly in relation to creative uses of technology. While this study was undertaken prior to the formal introduction of CS across Irish primary schools, the researchers' own experience of using these findings to inform family creative coding workshops has been found to be largely positive [8] and we believe that the instrument has potential both as a tool for gathering data to discern the level and form of assistance parents require to better support their children in their CS education and as an evaluation tool of such supports.

However, we also acknowledge that research into any interventions consequent to the measure needs to be cognisant of the complexities involved in delivery. As previously noted, there are many other relevant factors and variables involved in the successful implementation of PI initiatives [16] and issues around uptake and sustainability need to be addressed. The demographic make-up of participants also needs to be investigated. For example, the issue of gender (in light of the over-representation of female respondents in the sample) is of particular interest considering the under-representation of women in CS. Gender (of both the parent and child) is a particularly complex issue when it comes to PI having an impact on its quantity, nature, and outcomes [12, 58, 61].

Furthermore, as this was not an experimental research design, any claim for direction of causality is tentative. However, there are demonstrated correlations between the predictor and outcome variables and the causal hypothesis advanced is strongly supported by the literature, the focus groups (expert and target population), as well as the linear regression analysis of the survey results. In addition, we can claim that the instrument developed can be used in future experimental settings to measure the predictor and outcome variables and establish causation.

Overall, we argue that the validity and reliability of the developed scales is sufficient evidence for the use of the instrument in future research into PI in CS Education. Its potential contribution to evidence-based design should assist practitioners and researchers in providing parents with a positive experience of computing, and children with the parental support they need for success in the realm of CS.

APPENDIX

A PICS SURVEY INSTRUMENT

Availability

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

Usage: Creation

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

Usage: Consumption

Original Item Number	Question	Item Format	Item Values
12	What do you use these devices for in your home?	Checkboxes	- Browsing the Internet - Watching videos (YouTube, Vimeo) - Listening to Music - Playing Games - Online shopping - Video chat and voice calls (Skype, FaceTime...) - Sending and receiving email - Interacting with social media (Facebook, Twitter, Instagram,

Confidence

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

Attitude to PI in CS Education

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

Experience

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

Motivation for PI in CS Education

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

REFERENCES

[1] Accenture. 2015. Powering economic growth; attracting more young women into science and technology. Retrieved December 1, 2018 from https://www.accenture.com/ie-en/~/media/Accenture/Conversion-Assets/DotCom/Documents/Global/PDF/Dualpub_16/Accenture-Continuing-Power-Economic-Growth-Stem.pdf.

[2] Koen Aesaert, Johan van Braak, Daniël Van Nijlen, and Ruben Vanderlinde. 2015. Primary school pupils' ICT competences: Extensive model and scale development. *Comput. Educ.* 81 (2015), 326–344. DOI: https://doi.org/10.1016/j.compedu.2014.10.021

[3] Vassilis H. Aletras, Arsenis Kostarelis, Maria Tsitouridou, Dimitris Niakas, and Anna Nicolaou. 2010. Development and preliminary validation of a questionnaire to measure satisfaction with home care in Greece: an exploratory factor analysis of polychoric correlations. *BMC Health Serv. Res.* 10, 1 (2010), 189. DOI: https://doi.org/10.1186/1472-6963-10-189

[4] Khalid Abdullah Bingimlas. 2009. Barriers to the successful integration of ICT in teaching and learning environments: A review of the literature. *Eurasia J. Math. Sci. Technol. Educ.* 5, 3 (2009). DOI: https://doi.org/10.12973/ejmste/75275

[5] Francesca Borgonovi and Guillermo Montt. 2012. Parental involvement in selected PISA countries and economies. *OECD Educ. Work. Pap. No 73* (2012). DOI: https://doi.org/10.1787/5k990rk0jsjj-en

[6] Johan P. van Braak. 2004. Domains and determinants of university students' self-perceived computer competence. *Comput. Educ.* 43, 3 (2004), 299–312. DOI: https://doi.org/10.1016/j.compedu.2003.09.006

[7] Lisa Brahms. 2014. Making as a learning process: Identifying and supporting family learning in informal settings. Unpublished Ph.D. Dissertation. University of Pittsburgh, Pittsburgh, PA. Retrieved from http://d-scholarship.pitt.edu/21525/1/L_Brahms_ETD_2014.pdf.

[8] Nina Bresnihan, Glenn Strong, Lorraine Fisher, Richard Millwood, and Áine Lynch. 2019. OurKidsCode: Facilitating families to be creative with computing. In *Proceedings of the 11th International Conference on Computer Supported Education.* 519–530. DOI: https://doi.org/10.5220/0007729405190530

[9] John L. Campbell, Charles Quincy, Jordan Osserman, and Ove K. Pedersen. 2013. Coding in-depth semistructured interviews: Problems of unitization and intercoder reliability and agreement. *Sociol. Methods Res.* 42, 3 (2013), 294–320. DOI: https://doi.org/10.1177/0049124113500475

[10] Edward J. Cancio, Richard P. West, and K. Richard Young. 2004. Improving mathematics homework completion and accuracy of students with EBD through self-management and parent participation. *J. Emot. Behav. Disord.* 12, 1 (2004), 9–22. DOI: https://doi.org/10.1177/10634266040120010201

[11] Stéphane Chaudron, M. E. Beutel, Veronica Donoso Navarrete, M. Dreier, Ben Fletcher-Watson, A. S. Heikkilä, V. Kontríková, R. V. Korkeamäki, S. Livingstone, and J. Marsh. 2015. *Young Children (0-8) and Digital Technology: A Qualitative Exploratory Study Across Seven Countries.* Joint Research Centre of the European Commission, Luxembourg.

[12] Jody Clarke-Midura, Chongning Sun, Katarina Pantic, Frederick Poole, and Vicki Allan. 2019. Using informed design in informal computer science programs to increase youths' interest, self-efficacy, and perceptions of parental support. *ACM Trans. Comput. Educ.* 19, 4 (2019), 1–24. DOI: https://doi.org/10.1145/3319445

[13] Robert Coe, Michael Waring, Larry Hedges, and Arthur James. 2017. *Research Methods and Methodologies in Education* (2nd ed.). Sage, Thousand Oaks, CA.

[14] Kevin Crowley and Melanie Jacobs. 2002. Building islands of expertise in everyday family activity. In *Learning Conversations in Museums. Routledge*, New York, NY, 333–356.

[15] Quintin Cutts, Elizabeth Patitsas, Elizabeth Cole, Peter Donaldson, Bedour Alshaigy, Mirela Gutica, Arto Hellas, Edurne Larraza-Mendiluze, Robert McCartney, and Charles Riedesel. 2018. Early developmental activities and computing proficiency. In *Proceedings of the 2017 ITiCSE Conference on Working Group Reports.* ACM, 140–157. DOI: https://doi.org/10.1145/3174781.3174789

[16] Charles Desforges and Alberto Abouchaar. 2003. *The Impact of Parental Involvement, Parental Support and Family Education on Pupil Achievement and Adjustment: A Literature Review.* DfES Publications, Nottingham.

[17] Lance Emerson, Josh Fear, Stacey Fox, and Emma Sanders. 2012. *Parental Engagement in Learning and Schooling: Lessons from Research.* Australian Research Alliance for Children & Youth (ARACY) for the Family-School and Community Partnerships Bureau, Canberra.

[18] Joyce L. Epstein. 2001. *School, Family and Community Partnerships: Preparing Educators and Improving Schools.* Westview Press, Boulder, CO.

[19] Joyce L. Epstein, B. S. Simon, and Karen C. Salinas. 1997. Involving parents in homework in the middle grades. *Res. Bull.* 18, 4 (1997), 4.

[20] Andy Field. 2009. *Discovering Statistics Using SPSS* (3rd ed.). Sage.

[21] Christina Finn. 2014. A third of people think coding is more important than learning Irish. *Thejournal.ie.* Retrieved from http://www.thejournal.ie/coding-childrenschool-1729832-Oct2014/.

[22] Gallup and Google. 2015. Searching for computer science: Access and barriers in U.S. K-12 education. Retrieved May 19, 2017 from https://services.google.com/fh/files/misc/searching-for-computer-science_report.pdf.

[23] Wendy L. Goh, Susanna Bay, and Vivian Hsueh-Hua Chen. 2015. Young school children's use of digital devices and parental rules. *Telemat. Inform.* 32, 4 (2015), 787–795. DOI: https://doi.org/10.1016/j.tele.2015.04.002

[24] Janet Goodall and John Vorhaus. 2011. Review of best practice in parental engagement. Department for Education, London. Retrieved March 3, 2019 from https://dera.ioe.ac.uk/11926/1/DFE-RR156.pdf.

[25] Alma Harris and Janet Goodall. 2008. Do parents know they matter? Engaging all parents in learning. *Educ. Res.* 50, 3 (2008), 277–289. DOI: https://doi.org/10.1080/00131880802309424

[26] Stephen N. Haynes, David Richard, and Edward S. Kubany. 1995. Content validity in psychological assessment: A functional approach to concepts and methods. *Psychol. Assess.* 7, 3 (1995), 238. DOI: https://doi.org/10.1037/1040-3590.7.3.238

[27] Bruce Hayward, Carys Alty, Stephen Pearson, and Chris Martin. 2002. Young people and ICT 2002: Findings from a survey conducted in autumn 2002. British Department for Education and Skills, Coventry, UK. Retrieved July 4, 2019 from https://dera.ioe.ac.uk/1646/7/becta_2002_youngpeoplesuse_report_queensprinter_Redacted.pdf.

[28] D. Hooper, J. Coughlan, and M. R. Mullen. 2008. Structural equation modelling: guidelines for determining model fit. *Electron. J. Bus. Res. Methods* 6, 1 (2008), 53–60. DOI: https://doi.org/10.21427/D7CF7R

[29] Garry Hornby and Ian Blackwell. 2018. Barriers to parental involvement in education: An update. *Educ. Rev.* 70, 1 (2018), 109–119. DOI: https://doi.org/10.1080/00131911.2018.1388612

[30] Garry Hornby and Rayleen Lafaele. 2011. Barriers to parental involvement in education: An explanatory model. *Educ. Rev.* 63, 1 (2011), 37–52. DOI: https://doi.org/10.1080/00131911.2010.488049

[31] Li-tze Hu and Peter M. Bentler. 1999. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct. Eq. Model. Multidiscip. J.* 6, 1 (1999), 1–55. DOI: https://doi.org/10.1080/10705519909540118

[32] Janus Christian Jakobsen, Christian Gluud, Jørn Wetterslev, and Per Winkel. 2017. When and how should multiple imputation be used for handling missing data in randomised clinical trials–a practical guide with flowcharts. *BMC Med. Res. Methodol.* 17, 1 (2017), 162. DOI: https://doi.org/10.1186/s12874-017-0442-1

[33] Gail E. Jordan, Catherine E. Snow, and Michelle V. Porche. 2000. Project EASE: The effect of a family literacy project on kindergarten students' early literacy skills. *Read. Res. Q* 35, 4 (2000), 524–546. DOI: https://doi.org/10.1598/RRQ.35.4.5

[34] N. Keane and C. McInerney. 2016. Report on the provision of courses in computer science in upper second level education internationally. National Council for Curriculum and Assessment of Ireland. Retrieved June 14, 2018 from https://www.ncca.ie/media/2605/computer_science_report_sc.pdf.

[35] Siu-Cheung Kong, Robert Kwok-Yiu Li, and Ron Chi-Wai Kwok. 2018. Measuring parents' perceptions of programming education in P-12 schools: Scale development and validation. *J. Educ. Comput. Res.* 57, 5 (2018). DOI: https://doi.org/10.1177/0735633118783182

[36] Thomas R. Kratochwill, Lynn McDonald, Joel R. Levin, Holly Young Bear-Tibbetts, and Michelle K Demaray. 2004. Families and schools together: An experimental analysis of a parent-mediated multi-family group program for American Indian children. *J. Sch. Psychol.* 42, 5 (2004), 359–383. DOI: https://doi.org/10.1016/j.jsp.2004.08.001

[37] Ann L. LeFevre and Terry V. Shaw. 2012. Latino parent involvement and school success: Longitudinal effects of formal and informal support. *Educ. Urban Soc.* 44, 6 (2012), 707–723. DOI: https://doi.org/10.1177/0013124511406719

[38] Mark W. Lipsey, Kelly Puzio, Cathy Yun, Michael A. Hebert, Kasia Steinka-Fry, Mikel W. Cole, Megan Roberts, Karen S. Anthony, and Matthew D. Busick. 2012. Translating the statistical representation of the effects of education interventions into more readily interpretable forms. National Center for Special Education Research, Institute of Education Sciences, U.S. Department of Education., Washington, DC. Retrieved from http://ies.ed.gov/ncser/.

[39] Sonia Livingstone, Giovanna Mascheroni, Michael Dreier, Stephane Chaudron, and Kaat Lagae. 2015. How parents of young children manage digital devices at home: The role of income, education and parental style. LSE, London. Retrieved from http://eprints.lse.ac.uk/63378/1/__lse.ac.uk_storage_LIBRARY_Secondary_libfile_shared_repository_Content_EU%20Kids%20Online_EU_Kids_Online_How%20parents%20manage%20digital%20devices_2016.pdf.

[40] Yukiko Maruyama. 2019. An investigation into the effects of programming workshop experiences on parents' concerns about programming education in elementary school. In *Proceedings of the International Conference on Educational Technologies, International Association for Development of the Information Society (IADIS), Hong Kong.* 55. DOI: https://doi.org/10.33965/icedutech2019_201902l007

[41] Joseph A. Maxwell. 2004. Using qualitative methods for causal explanation. *Field Methods* 16, 3 (2004), 243–264. DOI: https://doi.org/10.1177/1525822x04266831

[42] Elisabeth R. McClure, Lisa Guernsey, Douglas H. Clements, Susan Nall Bales, Jennifer Nichols, Nat Kendall-Taylor, and Michael H. Levine. 2017. *STEM Starts Early: Grounding Science, Technology, Engineering, and Math Education in Early Childhood.* Joan Ganz Cooney Center at Sesame Workshop, New York.

[43] Monica M. McGill, Adrienne Decker, Tom McKlin, and Kathy Haynie. 2019. A gap analysis of noncognitive constructs in evaluation instruments designed for computing education. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education.* ACM, 706–712. DOI: https://doi.org/10.1145/3287324.3287362

[44] NCCA. 2019. Primary developments: Final report on the coding in primary schools initiative. *National Council for Curriculum and Assessment (NCCA).* Retrieved February 25, 2020 from https://ncca.ie/media/4155/primary-coding_final-report-on-the-coding-in-primary-schools-initiative.pdf.

[45] Leah O'Toole, Joan Kiely, and Deirdre McGillicuddy. 2019. Parental involvement, engagement and partnership in their children's education during the primary school years. *National Parents Council, Dublin.* Retrieved July 14, 2019 from https://researchrepository.ucd.ie/bitstream/10197/9823/2/Parental%20Involvement%20Research%20Doc.pdf.

[46] Hilda Pantin, J. Douglas Coatsworth, Daniel J. Feaster, Frederick L. Newman, Ervin Briones, Guillermo Prado, Seth J. Schwartz, and José Szapocznik. 2003. Familias unidas: The efficacy of an intervention to promote parental investment in hispanic immigrant families. *Prev. Sci* 4, 3 (2003), 189–201. DOI: https://doi.org/10.1023/A:1024601906942

[47] Eva M. Pomerantz, Elizabeth A. Moorman, and Scott D. Litwack. 2007. The how, whom, and why of parents' involvement in children's academic lives: More is not always better. *Rev. Educ. Res* 77, 3 (2007), 373–410. DOI: https://doi.org/10.3102/003465430305567

[48] Ricarose Roque, Karina Lin, and Richard Liuzzi. 2016. "I'm not just a mom": Parents developing multiple roles in creative computing. In *Proceedings of the International Society of the Learning Sciences (ICLS'16).* 663–671.

[49] Ofir Sadka and Oren Zuckerman. 2017. From parents to mentors: Parent-child interaction in co-making activities. In *Proceedings of the 2017 Conference on Interaction Design and Children.* ACM, 609–615. DOI: https://doi.org/10.1145/3078072.3084332

[50] Karin Schermelleh-Engel, Helfried Moosbrugger, and Hans Müller. 2003. Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods Psychol. Res. Online* 8, 2 (2003), 23–74.

[51] Arielle S. Selya, Jennifer S. Rose, Lisa C. Dierker, Donald Hedeker, and Robin J. Mermelstein. 2012. A practical guide to calculating Cohen's f2, a measure of local effect size, from PROC MIXED. *Front. Psychol.* 3, (2012), 111. DOI: https://doi.org/10.3389/fpsyg.2012.00111

[52] Prentice Starkey and Alice Klein. 2000. Fostering parental support for children's mathematical development: An intervention with head start families. *Early Educ. Dev.* 11, 5 (2000), 659–680. DOI: https://doi.org/10.1207/s15566935eed1105_7

[53] Kathy Sylva, Edward Melhuish, Pam Sammons, Iram Siraj-Blatchford, Brenda Taggart, Rebecca Smees, Anne Dobson, Marjorie Jeavons, Katie Lewis, and Maria Morahan. 2004. The effective provision of pre-school education (EPPE) project. Department for Education and Skills, London. Retrieved April 13, 2019 from https://dera.ioe.ac.uk/18189/2/SSU-SF-2004-01.pdf.

[54] Lori Takeuchi and Reed Stevens. 2011. *The New Coviewing: Designing for Learning Through Joint Media Engagement.* The Joan Ganz Cooney Center at Sesame Workshop, New York, NY.

[55] Lisa Towne and Richard J. Shavelson. 2002. *Scientific Research in Education.* ERIC.

[56] Rachel A. Vannatta and Savilla Banister. 2009. Validating a measure of teacher technology integration. In *Proceedings of the Society for Information Technology & Teacher Education International Conference (SITE'09).* Society for Information Technology & Teacher Education International Conference (AACE), Charleston, SC.

[57] Ioanna Vekiri. 2010. Boys' and girls' ICT beliefs: Do teachers matter? *Comput. Educ.* 55, 1 (2010), 16–23. DOI: https://doi.org/10.1016/j.compedu.2009.11.013

[58] Ioanna Vekiri and Anna Chronaki. 2008. Gender issues in technology use: Perceived social support, computer self-efficacy and value beliefs, and computer use beyond school. *Comput. Educ.* 51, 3 (2008), 1392–1404. DOI: https://doi.org/10.1016/j.compedu.2008.01.003

[59] Dawne S. Vogt, Daniel W. King, and Lynda A King. 2004. Focus groups in psychological assessment: enhancing content validity by consulting members of the target population. *Psychol. Assess.* 16, 3 (2004), 231. DOI: https://doi.org/10.1037/1040-3590.16.3.231

[60] Joke Voogt, Petra Fisser, Jon Good, Punya Mishra, and Aman Yadav. 2015. Computational thinking in compulsory education: Towards an agenda for research and practice. *Educ. Inf. Technol.* 20, 4 (2015), 715–728. DOI: https://doi.org/10.1007/s10639-015-9412-6

[61] Jennifer Wang, Hai Hong, Jason Ravitz, and Marielena Ivory. 2015. Gender differences in factors influencing pursuit of computer science and related fields. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education.* 117–122. DOI: https://doi.org/10.1145/2729094.2742611

[62] Blair Wheaton, Bengt Muthen, Duane F. Alwin, and Gene F. Summers. 1977. Assessing reliability and stability in panel models. *Sociol. Methodol.* 8, (1977), 84–136. DOI: https://doi.org/10.2307/270754

[63] Jeannette M. Wing. 2006. Computational Thinking. *Commun ACM* 49, 3 (2006), 33–35. DOI: https://doi.org/10.1145/1118178.1118215

[64] Gary K. W. Wong, Ho Yin Cheung, Edwin C. C. Ching, and John M. H. Huen. 2015. School perceptions of coding education in K-12: A large scale quantitative study to inform innovative practices. In *Proceedings of the 2015 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE'15).* IEEE, 5–10. DOI: https://doi.org/10.1109/tale.2015.7386007

[65] Roger L. Worthington and Tiffany A. Whittaker. 2006. Scale development research: A content analysis and recommendations for best practices. *Couns. Psychol.* 34, 6 (2006), 806–838. DOI: https://doi.org/10.1177/0011000006288127

[66] Zhi-Jin Zhong. 2011. From access to usage: The divide of self-reported digital skills among adolescents. *Comput. Educ.* 56, 3 (2011), 736–746. DOI: https://doi.org/10.1016/j.compedu.2010.10.016

Received February 2019; revised November 2020; accepted November 2020