Female participation in school computing: reversing the trend

June 2016

ACCE
AUSTRALIAN COUNCIL FOR COMPUTERS IN EDUCATION

digitalcareers
Engaging Young Minds towards Australia's Digital Future

intel

Foreword

Women were once leading innovators in computing and information technologies – think Ada Lovelace, who wrote the first computer algorithm in the nineteenth century.

Fast forward to the 21st century, only one in ten graduates from IT degrees in Australia are women.

The reasons for this precipitous decline are many and varied – and they're canvassed in this report commissioned by Digital Careers and sponsored by Intel Australia.

From the 'short poppy syndrome' to persistent stereotypes about ICT being the domain of geeky boys, the result is clear: girls are missing out on learning skills that are becoming increasingly more important and valued.

This research is important because it evaluates the solutions, which is necessary. If it was a straightforward issue, we would have solved this issue a long time ago.

There's a powerful push underway in the technology sector to attract and retain women into its ranks.

For businesses, the opportunity is clear: a company's ability to design products to meet the needs of both females and males is more likely to benefit from having more females in innovation and leadership positions. Furthermore, diverse organisations are smarter organisations – all of the research backs this.

Most importantly, it's the right thing to do.

We live in an age where technology underpins a lot of innovation in our economy; where the 'jobs of the future' are requiring higher and higher levels of digital literacy.

The digital economy in Australia is growing at twice the rate of the rest of the economy. Over the next five years, Australia will need an extra 100,000 workers to meet this growth.

Women and girls should be getting their fair share of these jobs. This can't happen without the right education or the confidence to seek these jobs.

The world of technological innovation is an exciting one that sparks the imagination and allows us to invent the future. The time is right for industry to examine the evidence base, learn from mistakes of the past and play a key role in delivering system-wide change to support girls to have the confidence and passion to take up IT as a career.

Kate Burleigh,
Managing Director, Intel Australia

Executive summary

Computer education, with a focus on Computer Science, has become a core subject in the Australian Curriculum and the focus of national innovation initiatives. Equal participation by girls, however, remains unlikely based on their engagement with computing in recent decades.

In seeking to understand why this may be the case, a Delphi consensus process was conducted using a wide range of experts from industry and academia to explore existing research and interventions, recommending four key approaches: engaging girls in the Digital Technologies curriculum; addressing parental preconceptions and influences; providing positive role models and mentors; and supporting code clubs for girls.

Unfortunately, all of these approaches have been widely implemented, and while individually successful at the scale of their implementation, have failed to systemically improve female participation in computing. The only discernible difference between initiatives to improve female participation in computing and the successful approaches in other fields such as science, has been the availability of a compulsory developmental curriculum beginning from the start of school, and it is this that may provide a scaffold that sustains female engagement over critical periods such as adolescence, when participation in computing begins to dramatically decline.

Dr Jason Zagami
Griffth University, Australia

Dr Marie Boden
University of Queensland, Australia

Dr Therese Keane
Swinburne University of Technology

Bronwyn Moreton
President of Robocup Jnr NSW, Australia

Dr Karsten Schulz
Digital Careers, Australia

Introduction

Computing occupations are predicted to make up two thirds of all new jobs in STEM (*Science, Technology, Engineering & Mathematics*) related fields (*Bureau of Labor Statistics Employment Projections, 2015; elaborated by Code.Org, 2015*) and Computer Science education has risen to prominence to become a national priority (*Department of Industry, Innovation and Science, 2015*). Computer Science education has been highlighted as an essential subject for Australian students in political debate (*Aynsley, 2015; Spencer, 2015; Shorten, 2015; Turnbull, 2014*) and in 2015 it was incorporated into Australian compulsory school curricula for the first time (*Pyne, 2015*). But will all Australian children have equal opportunities to take advantage of the opportunities envisaged and engage with the new Computer Science curriculum?

The percentage of women participating in many STEM areas has been steadily increasing, and in some areas achieving parity (*Figure 1*). However the number of women participating in Computer Science has continued to steadily decrease since the mid 80's. US workforce statistics show a peak of almost 40% in the mid 80's, to less than 30% in 1995, and less than 20% in 2015 (*National Science Foundation, 2015*); and the US National Science Board (*2012*) reported female participation in Computer Science declining to 18% in 2012 from a 37% peak in the mid 80's (*Figure 1*).

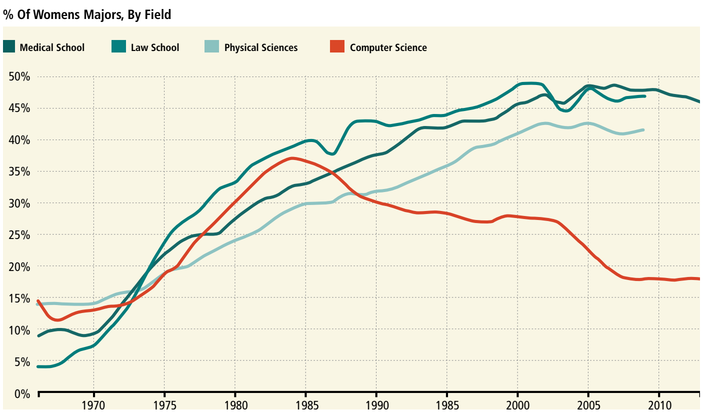

Figure 1. Participation of Women by Field. Reprinted from "When Women Stopped Coding", 2015, NPR.

A broad spectrum of strategies has been used to improve female participation in many fields, with considerable success in mathematics and science education (*Brotman & Moore, 2008*). Computer Science education however remains intransigent, and while substantial effort has been put into intervention programs and a significant body of research conducted to ascertain the effectiveness of these interventions, they have not resulted in systemic improvements in participation rates. Australian university enrolment data shows that 5% of university students are pursuing courses in the Information Technology Field of Education (*FOE*), one of the 10 FOE's, and female participation of this 5% is less than 20% (*Table 1*). The Information Technology Field of Education includes studies related to computation theory, computer programming, data format and coding, management, storage and retrieval of information in a computer environment, robotics programming and artificial intelligence, and systems analysis (*Department of Education and Training, 2016*).

Table 1. University Enrolments in Information Technology FOE

Year	Male	Female	Total	% Female
2014	46519	10772	57291	18.80%
2013	42526	9907	52433	18.89%
2012	40433	9723	50156	19.39%
2011	39992	9891	49883	19.83%
2010	40805	9842	50647	19.43%
2009	40798	10119	50917	19.87%
2008	39648	9547	49195	19.41%
2007	41152	9725	50877	19.11%

Adapted from uCube
http://highereducationstatistics.education.gov.au/

While university female participation rates are low, senior school female participation rates in computer education are lower still. Student participation in senior high school computing subjects in Australia's three most populous states, show a sustained decline from around 19000 in 2007 to 13000 in 2015, a decrease of 32% (*Tables 2, 3 & 4*), and the percentage of females participating in this declining number has also decreased, compounding the gender disparity. For senior general computing subjects, in Queensland (*ITS*) there has been a decline of 5.3% from 33.5% to 28.3% (*QLD*), in NSW (*IPT*) there was a decline of 9.6% from 29% to 19.4% and in Victoria there has been a decline in the two general computing subjects of 10.1%(*ITApp*)/12.2%(*IT*) from 25.8%/26.9% to 15.7%/14.7%(*2013*). For computer science based subjects, the decline in Queensland (*IPT*) has been 6.4% from 18.7% to 12.3%, in NSW (*SDD*) 1.9% from 7.7% to 5.8%, and in Victoria (*SD*) 1.9% from 7% to 5.1%. To reiterate, currently the participation rates of females in senior computer science courses are 12.3% (*QLD, Information Processing and Technology, IPT*), 5.8% (*NSW, Software Design & Development, SDD*) and 6.2% (*VIC, Software Development, SD*), an average of 8.6% (*473 female students from 5507 students*).

While university female participation rates are low, senior school female participation rates in computer education are lower still. Student participation in senior high school computing subjects in Australia's three most populous states, show a sustained decline from around 19000 in 2007 to 13000 in 2015, a decrease of 32% (*Tables 2, 3 & 4*), and the percentage of females participating in this declining number has also decreased, compounding the gender disparity. For senior general computing subjects, in Queensland (*ITS*) there has been a decline of 5.3% from 33.5% to 28.3% (*QLD*), in NSW (*IPT*) there was a decline of 9.6% from 29% to 19.4% and in Victoria there has been a decline in the two general computing subjects of 10.1%(*ITApp*)/12.2%(*IT*) from 25.8%/26.9% to 15.7%/14.7%(*2013*). For computer science based subjects, the decline in Queensland (*IPT*) has been 6.4% from 18.7% to 12.3%, in NSW (*SDD*) 1.9% from 7.7% to 5.8%, and in Victoria (*SD*) 1.9% from 7% to 5.1%. To reiterate, currently the participation rates of females in senior computer science courses are 12.3% (*QLD, Information Processing and Technology, IPT*), 5.8% (*NSW, Software Design & Development, SDD*) and 6.2% (*VIC, Software Development, SD*), an average of 8.6% (*473 female students from 5507 students*).

Table 2. Enrolments QLD Computing Subjects

Year	Subject	Females	Enrolments
2015	IPT	12.3%	2268
2015	ITS	28.3%	3024
2014	IPT	12.6%	2265
2014	ITS	26.4%	3037
2013	IPT	14.1%	2050
2013	ITS	31%	2786
2012	IPT	14.8%	2278
2012	ITS	30.6%	2899
2011	IPT	15.8%	2347
2011	ITS	34.4%	2682
2010	IPT	16.6%	2488
2010	ITS	35.9%	3017
2009	IPT	16.5%	2625
2009	ITS	36.8%	2949
2008	IPT	18.6%	2982
2008	ITS	36.1%	2351
2007	IPT	18.7%	3330
2007	ITS	33.5%	2124

Adapted from Subject enrolments and levels of achievement 2007-2015
https://www.qcaa.qld.edu.au/publications/statistics

Table 3. Enrolments NSW Computing Subjects

Year	Subject	Females	Enrolments
2015	SDD	5.8%	1879
2015	IPT	19.4%	3047
2014	SDD	6.8%	1781
2014	IPT	21.9%	3052
2013	SDD	7.4%	1663
2013	IPT	23.5%	3240
2012	SDD	6.5%	1534
2012	IPT	23%	3517
2011	SDD	7.1%	1687
2011	IPT	26.3%	4453
2010	SDD	9.3%	1820
2010	IPT	27.2%	4967
2009	SDD	8.7%	1785
2009	IPT	28.2%	5346
2008	SDD	9.3%	1876
2008	IPT	28.5%	5411
2007	SDD	7.7%	1887
2007	IPT	29%	5445

Adapted from UAC ATAR Scaling Reports 2007-2015
http://www.uac.edu.au/

Table 4. Enrolments Victorian Computing Subjects

Year	Subject	Females	Enrolments
2015	SD	6.2%	1360
2015	ITApp	15.7%	2496
2014	SD	5.6%	1255
2014	ITApp	16%	2369
2013	SD	5.7%	1373
2013	IT	14.8%	4657
2013	ITApp	16.1%	2701
2012	SD	5.1%	1091
2012	ITApp	17%	2881
2012	IT	16.5%	4985
2011	SD	7.1%	1349
2011	ITApp	18.8%	3247
2011	IT	17.5%	5161
2010	SD	8.3%	1257
2010	ITApp	21.4%	3649
2010	IT	19.7%	5804
2009	SD	5.1%	1353
2009	ITApp	23.6%	4286
2009	IT	24.9%	6977
2008	SD	6.6%	1432
2008	ITApp	26.3%	4147
2008	IT	26.2%	7491
2007	SD	7%	1564
2007	ITApp	25.8%	4749
2007	IT	26.9%	7231

Adapted from Grade Distributions for Graded Assessments VCE 2007-2015
http://www.vcaa.vic.edu.au/

While comprehensive data is not available for primary and lower secondary computing before 2016, as there was no systematic computing curriculum, some data is available from extra curricula programs that have engaged students with computer science. The Bebras competition is an extracurricular online test comprising short computer science tasks. 2015 participation data in the competition from over 16900 Australian students from year 3 to 12 suggests female disengagement with Computer Science may begin around the commencement of high school, with female participation in this extra curricula activity decreasing from parity (*50%*) in primary school to 20% by the end of high school (*Figure 2*).

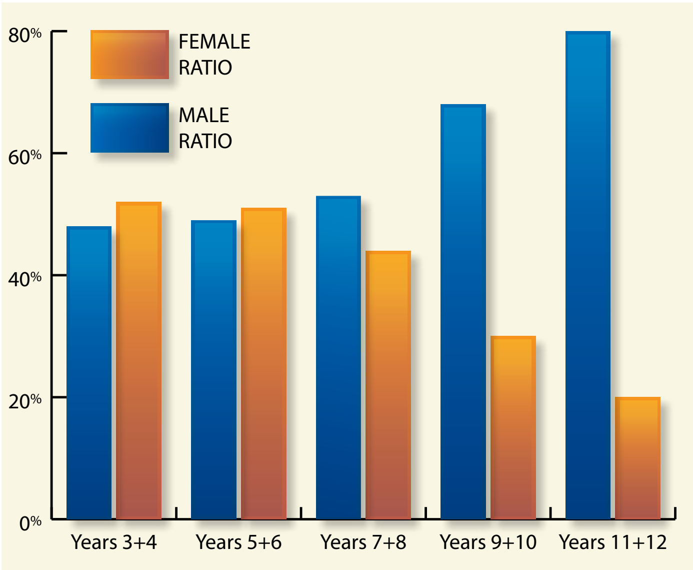

Figure 2. Participation in the 2015 Australian Bebras Computing Challenge by gender (Bebras Participation Rates, Schulz, 2015).

Within this context, a research process was commenced to understand why female participation rates in schools are so low, the attempts that have been made to address low participation rates of school age girls, and which of the approaches are most likely to have the strongest impact on female participation rates in schools.

Literature

To understand the body of research on female participation in computing, an expert panel examined over a hundred Australian and international research publications, with this research categorised into three primary factors: Essentialist, Social-cultural and Structural (*Osunde, Windall, Bacon, & Mackinnon, 2014*). Essentialist factors related to disparity caused by inherent differences between males and females such as mathematical competence and computational thinking ability; Socio-cultural factors suggest that the differences are caused by external (*e.g. stereotyping*) and internal (*e.g. self-expectation*) factors which influence the development of males and females; and Structural factors suggest that disparities are caused by the nature of institutions (*home, education and industry*) such that they limit opportunities for girls to increase in representation without structured intervention. The review also examined wider research on female participation research, particularly in science, mathematics and engineering school education.

Ten key articles were then selected by use of a Delphi research process amongst the expert panel, and used to inform participants in later stages of the project and the analysis process. Nine articles focused on Socio-cultural factors, one article focused on Structural factors, and interestingly, no key article was selected that focused on Essentialist factors. This emphasis on Socio-cultural factors, with gender differences caused primarily by self-confidence and motivation, and identity related stereotypes, was strongly evident in the selected research literature. This may reflect the relative emphasis on intervention programs, and the relative difficulties in interventions that address Essentialist and Structural factors. It also indicates a gap in the body of research, with researcher preferences on Socio-cultural factors dominating the discourse in both the literature and the expert panel.

Of the nine socio-cultural articles, five focused on category membership stereotypes (*Cheryan, Master, & Meltzoff, 2015; Pechtelidis, Kosma, & Chronaki, 2015; Yansen & Zukerfeld, 2014; Lang, 2012*) and strategies to negate or mitigate stereotypes. Three articles explored social learning (*Pechtelidis, Kosma, & Chronaki, 2015; Yansen & Zukerfeld, 2014; Christoph, Goldhammer, Zylka, & Hartig, 2015*) as an effective strategy to engage female students with Computer Science, one article addressed

Encouragement, Role Models /Mentoring, Gender Grouping, Educational Policy Reform, and Educational Games (*Trauth, Quesenberry, & Morgan, 2004*), two articles addressed Encouragement, Role Models/ Mentoring, and Awareness Raising (*Nelson, 2014, Moakler & Kim, 2014*), and a final article defied categorisation (*Gras-Velazquez, Joyce, & Debry, 2009*) on why girls are not attracted to ICT studies and careers. The only non Socio-cultural factor paper, focused on Structural factors (*Google, 2014*) addressing issues of Student Encouragement and Educational Policy Reform with four key influencing factors identified as:

1. **Social Encouragement:** Positive reinforcement of Computer Science pursuits from family and peers.
2. **Self-Perception:** An interest in puzzles and problem solving and a belief that those skills can be translated to a successful career.
3. **Academic Exposure:** The availability of, and opportunity to participate in, structured (*e.g., graded studies*) and unstructured (*e.g., after-school programs*) Computer Science coursework.
4. **Career Perception:** The familiarity with, and perception of, Computer Science as a career with diverse applications and a broad potential for positive societal impact.

Method

In 2015 a panel of seven experts in female participation in computing was brought together from across Australia by Digital Careers with the aim of better understanding current initiatives in female participation in K12 computer science in Australia, and prepare this report to assist Digital Careers in prioritising efforts to improve female participation in computing. The expert panel included academics, computer education professional association leaders, and female participation initiative leaders.

A qualitative, participatory action research process was applied using a modified Delphi process for consensus analysis of the issues and initiatives related to improving female participation in computer science, and was implemented over a 5 month period, in five phases. The Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise, and this research used a series of Delphi studies, where each phase informed the development of a consensus in the next, with the aim of establishing an expert consensus on the available research, public opinions on available female participation initiatives, expert consensus on this opinion, and finally interest group opinion on the derived expert opinion. In more detail this process involved:

1. Review of existing research (*100 articles*) by the expert panel with consensus developed on a set of 10 key research articles that would inform the expert panel and public participants in further stages;
2. Contribution from the public (*42 contributions or votes*) of ideas (*22 contributed ideas*) related to why girls do not participate fully in computer education;
3. Refinement of contributed ideas by expert panel consensus to select the best 12, and assign groups to examine these selected idea's, supported by an assigned expert panel mentor to discuss and develop each idea into potential solutions;
4. Feedback was then sought from 20 interest groups drawn from the computing industry, educational organisations, and female participation initiative groups, on the 12 developed ideas to refine these to 4 selected ideas; and
5. Analysis of results from the research informed by the consensus process and comparing this to available research and participation trends.

Strategies

The research developed a consensus of views, with participation from a wide range of individuals and interest groups including professional associations (*7*), female participation initiative groups (*12*), academics (*8*), IT companies (*5*), teachers (*6*), and students (*9*). The resulting views of suitable approaches to improving female participation in K-12 Computer Science have been presented in summary, categorised by factors (*Osunde, Windall, Bacon, & Mackinnon, 2014*), and four specific cases expanded upon in order to explore in greater depth a set of approaches to improving female participation in K-12 Computer Science:

1. Engaging girls in the Digital Technologies Curriculum;
2. Parental preconceptions and influences;
3. Role Models and Mentors; and
4. Digital Technologies Activities for Girls.

Contributions from the modified Delphi process identified 12 strategies and program examples that are commonly used and likely to improve female participation in K-12 Computer Science.

STRATEGY	FOCUS	CATEGORY	SOLUTION TYPES
Short Poppy Syndrome	Naive teacher perceptions of talent in Computing are influencing female self efficacy in computing, a stronger focus on the development of higher order thinking skills in primary schools through Computer Science may build student resilience and challenge teacher perceptions.	Social cultural factors	Stereotypes Category membership), Awareness raising, Educational policy reform.
Evaluating interventions	Evaluation of programs to engage young people in Computer Science are not well developed and potentially gender biased, the construction of a conceptual framework to evaluate intervention programs could assist in improving them.	Social cultural factors	The construction of a conceptual framework.
10 and over	Early intervention is needed to engage young people with technology before the age of 10, and especially girls, with the support of specialist primary Computer Science teachers.	Social cultural factors	Encouragement, Role models / mentoring, Specialist teachers, Gender grouping, Educational policy reform.
Code XX Programming for Girls	Girls sometimes find it difficult to engage equally in traditionally male dominated subjects such as computing. Courses-for girls only that take advantage of preferences for non competitive and social learning opportuni-ties may improve female participation.	Social cultural factors	Encouragement, Gender grouping, Social Learning (preference to learn in groups), Educational games.
Lets ask the girls!	Research into gender issues is often focused on a wide range of factors, drawn from gender studies and other fields of academic endeavour, without specifically find-ing out what girls them-selves want. Conducting research into the views of Australian girls at various-ly age levels is a significant part of research into female participation.	Social-cultural and Structural factors	An online questionnaire surveying high school and university girls about their thinking around technology (ICT)
WSTEM	Mentoring programs for girls studying Computer Science can strengthen female confidence around computing, provide networks and foster a community of female students in STEM.	Structural factors	Encouragement, Gender grouping, Role models / mentoring
Prose for programming	Incorporating activities such as written or spoken prose and lyrics into the teaching of Computer Science may engage female students by providing them with a foundation in an area of strength and interest.	Essentialist factors	Gender grouping, Social Learning
Girls Programming Networks	Networking opportunities are needed to provide girls with interesting and challenging activities, in fun and positive environments.	Social-cultural factors	Encouragement, Role models / mentoring, Gender grouping
Improving the curriculum in schools to engage girls	This idea or challenge is "Current school IT curricula does not inspire or interest girls this is a major reason why girls do not go on to study IT further"	social-cultural and structural	Stereotypes (category membership), Role models / mentoring, Social Learning (preference to learn in groups), Educational policy reform.
MOBEEAS Role Models and Mentors	To encourage female participation in computing at school by facilitating contact with young enthusiastic and capable role models.	Structural factors	Encouragement, Role models / mentoring, and Awareness raising.
Improving the curriculum in schools to engage girls	Computer Science education resources may not be supportive of female student engagement and learning of the Digital Technologies curriculum	Social-cultural and structural	Stereotypes (category membership), Role models / mentoring, Social Learning (preference to learn in groups), Educational policy reform.
Parental preconception and influences	Parents are often not aware of the careers available in Computer Science and strategies available to improve understanding and address misconceptions..	Social-cultural	Encouragement, Role models / mentoring, and Awareness raising.

From the 12 strategies / example programs selected by the public Delphi process, and in some cases an amalgamation of suggested strategies and programs, the four most promising strategies were selected, again from a Delphi consensus voting process, this time conducted by the expert panel, and explored in detail by focus groups drawn from academic, industry and professional association groups over a two month period, resulting in 4 suggested strategies:

1. Engaging girls in the Digital Technologies Curriculum;
2. Parental preconceptions and influences;
3. Role Models and Mentors; and
4. Digital Technologies activities for girls.

Strategy 1.

Engaging girls in the Digital Technologies curriculum

Problem
Some existing Computer Science education resources may not be supportive of female student engagement and learning of the Digital Technologies curriculum.

Aim
The aim of this strategy is to ensure that the Digital Technologies curriculum supports the interests and learning of female students.

Approach
The duration and development of gender inclusive or neutral Computer Science activities to support the teaching of the Digital Technologies curriculum. Research is needed to map existing resources with respect to the curriculum and to identify appropriate resources and pedagogical approaches, particularly in addressing potential essentialist factors related to gendered brain development, and structural factors related to contextual choices made for computer education activities.

Strategy 2.

Parental preconceptions and influences

Problem
Parents and relatives of young girls are often not aware of what careers and professions the study of Computer Science can lead to for their daughters, and subsequently many parents do not see computing or engineering as a possible future profession for their daughters.

Aim
To inform parents about the wide variety of computing professions available and the possibilities for women in computing related careers and to identify perceptions among parents and relatives and address misconceptions by organising workshops and engagement activities that include parents, relatives and girls.

Approach
Workshops in schools and articles in parent magazines and school newsletters featuring female university computing students who promote computer studies and highlight careers pathways.

Strategy 3.

Role Models and Mentors

Problem
Exposure to inspirational role models play an important part in the career selection process of young woman but access to female role models in computing related careers is often limited.

Aim
To ensure that female students have opportunities to develop role models that are supportive of study and career opportunities in computing, and mentors that can prove direct support.

Approach
To create opportunities for accomplished academics, professionals and university students to mentor school-aged students via well-orchestrated self-perpetuating mentor programs. To support mentorships, databases of mentors and structures to manage the assignment and support of mentors with schools and individual students may be required, as well as structures to support schools, teachers and students with the mentoring process.

Strategy 4.

Code clubs for girls

Problem
Many existing code club initiatives have predominantly male participation and girls are sometime more engaged with programs that are differentiated and designed to cater specifically for female interests.

Aim
To provide code club opportunities for girls that cater for their interests and enable girls to socialise with other girls interested in Computer Science. This will give girls exposure to Computer Science and encourage them to consider computing studies and careers.

Approach
To support code club initiatives, particularly in early primary and late secondary school grades, when differentiated programs are less impacted by developmental social pressure.

Findings

Four specific strategies identified by the Delphi process were selected as those most likely to be effective approaches to addressing low participation of females in K-12 Computer Science in the current Australian context:

1. Engaging girls in the Digital Technologies Curriculum;
2. Parental preconceptions and influences;
3. Role Models and Mentors; and
4. Digital Technologies activities for girls.

An important caveat to this identification was a growing understanding through the research process that no one strategy is the optimal approach, and that combinations and a broad range of strategies are likely necessary to address female underrepresentation. It was however beyond the scope of this study to explore what minimum or optimal combinations would be required.

The review of the literature with respect to general initiatives to improve female participation in education also highlighted two key factors with respect to the strategies employed in computer science education and other educational fields:

1. There is no fundamental difference between types of female participation initiatives implemented in the past two decades to improve female participation in computing and those implemented in similar disciplines such as science and mathematics (*Herz, 1991*).
2. While similar approaches to improve female participation in other fields have been successful in reversing downward trends and improving participation, computing participation has not shown improvement, with computing participation continuing to decline (*NPR, 2015*).

All of the strategies identified through the research process have been implemented many times in the past, and while all initiatives reported positive impact in described research, female participation rate data over the last decade suggests that these efforts have not been sufficient, either through scale of implementation or long term effect, to address the overall decline in female participation in Computer Science.

The question thus arises: what factors are different between computer science and fields that have shown sustained success in engaging females? Socio-cultural factors were in the main similar, as were essentialist factors. Most structural factors were similar, such as support from parents and industry (*Tobias, 1992*), but a key structural factor at variance is how the discipline is treated in school curricula.

Mathematics and science education have had a strong mandatory curriculum framework stretching from school entry to the end of compulsory schooling since curriculum reforms in the 1960's (*Matthews, 1990*).
This has potentially provided a scaffold upon which intervention initiatives were supported and benefits sustained. Computing has lacked this developmental curriculum, with uncoordinated and one off courses, if any, included in the curriculum, and these predominantly in secondary school (*Brotman & Moore, 2008*).

The review of research literature showed that almost all initiatives and interventions to address female participation in computing have occurred extra curricula, and this in itself may have contributed to a negative impression of computer science, particularly in early adolescence when socio-cultural factors (*Osunde, Windall, Bacon, & Mackinnon, 2014*) such as peer acceptance is a priority for many females, and initiatives that differentiate themselves from the norm may be counterproductive at this age in student identity development, and notably is the age at which student engagement with computing begins to decline in the Bebras initiative (*Schulz, 2015*).

Recommendations

While further research is required to determine if a curriculum framework provides sufficient sustained engagement to reverse the declining female participation trend in school computer science education, it does provide a possible systemic solution to what has been otherwise an intractable problem. This research suggests that in supporting initiatives to increase female participation in computing:

1. A broad range of initiatives continue to be supported, with priority on the four strategies identified; Engaging girls in the Digital Technologies Curriculum; Parental preconceptions and influences; Role Models and Mentors; and Digital Technologies Activities for Girls;

2. Consideration be given to prioritising initiatives that integrate with the school curriculum, especially the F-10 Digital Technologies subject, to normalise and sustain the effects of initiatives; and

3. Consideration be given to prioritising initiatives that have a sustained progression, building on student participation and sustaining their interest in computing, particularly over the key period of Years 7 - 8 when female participation begins to decline.

With the introduction of a developmental computer science discipline within Australian compulsory schooling, the compulsory Digital Technologies curriculum may provide a framework upon which female participation in computing can be addressed. As with participation in mathematics and science curriculum, addressing the lack of female participation in computer science will likely require the sustained efforts of a wide range of programs and initiatives in addition to the new curriculum, and improvements may take several years to become evident, but the importance of full female participation in increasing important computing related industries, is of vital importance to Australian industry and society.

Acknowledgements

Report prepared by

Dr Jason Zagami
Griffith University, Australia

Dr Marie Boden
University of Queensland, Australia

Dr Therese Keane
Swinburne University of Technology

Bronwyn Moreton
President of Robocup Jnr NSW, Australia

Dr Karsten Schulz
Digital Careers, Australia

Research contribution made from:

Jenine Beekhuyzen
Girls Tech Movement

Dr Bernardo Leon de la Barra
University of Tasmania

Research supported by

Digital Careers

Intel Australia

Australian Council for
Computers in Education

Research data available from
http://jzagami.info/wordpress/research/girls-computing/

Cover Image:
Young woman looking with futuristic smart high tech glasses ID 50453029 © Rancz Andrei Licensed from Dreamstime.com to ACCE

Other Images:
Photographs courtesy of Young ICT Explorers, a youth technology challenge driven by SAP and Digital Careers. Image on page 9. courtesy of Digital Careers

References

Aynsley, B. (2015, April 14). Equipping kids with digital skills key to future success. *The Australian Business Review.* Retrieved from http://www.theaustralian.com.au/business/technology/equipping-kids-with-digital-skills-key-to-future-success/story-e6frgb0o-1227302409131

Bureau of Labor Statistics Employment Projections. (2015). Retrieved from http://www.bls.gov/emp/tables.htm

Brotman, J., & Moore, F. (2008). Girls and science: A review of four themes in the science education literature. *Journal of research in science teaching, 45(9), 971.*

Cheryan, S., Master, A., & Meltzoff, A. (2015). Cultural stereotypes as gatekeepers: increasing girls' interest in Computer Science and engineering by diversifying stereotypes. *Frontiers in psychology, 6.*

Christoph, G., Goldhammer, F., Zylka, J., & Hartig, J. (2015). Adolescents' computer performance: The role of self-concept and motivational aspects. *Computers & Education, 81,* 1-12.

Code.Org. (2015). Summary of source data for Code.org infographics and stats. Retrieved from https://docs.google.com/document/d/1gySkItxiJn_vwb8HIIKNXqen184mRtzDX12cux0ZgZk/pub

Google. (2014). Women Who Choose Computer Science - What Really Matters. Retrieved November 2, 2015, from http://static.googleusercontent.com/media/www.wenca.cn/en/us/edu/pdf/women-who-choose-what-really.pdf.

Gras-Velazquez, A., Joyce, A., & Debry, M. (2009). Women and ICT: Why are girls still not attracted to ICT studies and careers?. European Schoolnet.

Lang, C. (2012). Sequential attrition of secondary school student interest in IT courses and careers. *Information Technology & People, 25*(3), 281-299.

Moakler, M., & Kim, M. (2014). College Major Choice in STEM: Revisiting Confidence and Demographic Factors. *The Career Development Quarterly, 62*(2), 128-142.

National Science Board (2012). Science and Engineering Indicators. Retrieved from http://www.nsf.gov/statistics/seind12/

National Science Foundation (2015). Retrieved from http://nsf.gov/statistics/2015/nsf15311/digest/theme2.cfm#compsci

Nelson, B. (2014). The data on diversity. *Communications of the ACM, 57*(11), 86-95.

NPR (2015). When Women Stopped Coding. Retrieved from http://www.npr.org/sections/money/2014/10/21/357629765/when-women-stopped-coding

OECD (2015), The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence, PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264229945-en

Osunde, J., Windall, G., Bacon, L., & Mackinnon, L. (2014). Female Underrepresentation in Computing Education and Industry - A Survey of Issues and Interventions. *International Journal of Advanced Computer Science and Applications, 5*(10).

Pechtelidis, Y., Kosma, Y., & Chronaki, A. (2015). Between a rock and a hard place: women and computer technology. *Gender and Education, 27*(2), 164-182.

Pyne, C. (2015, September 18). *A new national curriculum from 2016.* [Press release]. Canberra, Australia: AGPS. Retrieved from https://ministers.education.gov.au/pyne/new-national-curriculum-2016

Shorten, B. (2015, May 14). *Budget Reply Speech.* [Speech]. Canberra, Australia: AGPS. Retrieved from http://www.alp.org.au/budget_reply_speech

Spencer, L. (2015, February 20). Turnbull calls for earlier introduction of coding in schools. *ZDNet.* Retrieved from http://www.zdnet.com/article/turnbull-calls-for-earlier-introduction-of-coding-in-schools/

Trauth, E. M., Quesenberry, J. L., & Morgan, A. J. (2004). *Understanding the underrepresentation of women in IT: toward a theory of individual differences. Proceedings of the 2004 SIGMIS conference on Computer personnel research: Careers, culture, and ethics in a networked environment.* ACM.

Turnbull, M. (2014, October 24). *The Importance of Tech Education in Our Schools.* [Speech]. Canberra, Australia: AGPS. Retrieved from http://www.malcolmturnbull.com.au/media/speech-the-importance-of-tech-education-in-our-schools

Yansen, G., & Zukerfeld, M. (2014). Why Don't Women Program? Exploring Links between Gender, Technology and Software. Science Technology & Society, 19(3), 305-329.

digitalcareers

PO Box 10522
Adelaide Street, Brisbane, QLD, 4000
70–72 Bowen Street, Spring Hill, QLD, 4000

www.digitalcareers.edu.au
twitter:@digicareersau
www.facebook.com/digitalcareersau

BDOO59-DC-REPORT/08/06/2016