Relational sensibilities and women's participation in computer science and information technology degrees: A cultural-historical approach☆

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ABSTRACT

There is extensive literature concerning women's low participation in the technology industry. However, little is known about the relational aspect of women's participation in information technology–related degrees. This study focused mainly on relational sensibility and women's experience of the situation as it is, and how they imagine it could be and should be, as potential life projects are formulated in relation to, and with, others as they engage in 4-year undergraduate degrees in computer science (CS) or information technology (IT). Data were generated from five semi-structured interviews and a focus group discussion with seven women ($n = 12$ participants). The women in this study enrolled in an undergraduate degree as they were able to solve complex IT problems by themselves and then help others. Further, the self-positioning and the positioning by others created emotional tension and effected the women's relational sensibilities. Most of the women were undecided about their future career in IT because of the lack of transparency and information about what is involved in employment in the field. We argue that moral imagination provides a different perspective to understand women's underrepresentation in the CS and IT fields.

1. Introduction

Over the last three decades, the increasing use of technology within industry and everyday life has positioned the field as a high-growth sector. Yet, since the 1980s, there have been concerns regarding the low number of women engaging in the fields of science, technology, engineering and mathematics (STEM), and specifically the information technology (IT) sector (Thébaud & Charles, 2018). Despite efforts to understand underlying scientific reasons and implement programmes to support the attraction and retention, and lessen the attrition, of women engaged in the IT pathway, the problem persists (Aspray, 2016). It appears that the studies have had little impact on women's participation and engagement in the field, and we still do not fully understand why there continues to be low numbers of women enrolling in IT degrees, what would attract more women into degrees, and what would contribute to their retention

as they graduate and enter into employment in the field.

There are a few countries where women's rate of participation in IT degrees equals or surpasses that of men, such as Afghanistan (see Hoffmann, 2010), India (see Gupta, 2012) and Malaysia (Mellström, 2009). In these countries, employment in the industry is understood as a suitable career choice for women as it is situated in an office and outside physical tasks are not involved (Gupta, 2012). In Malaysia, according to Mellström (2009), the government decrees gender- and race-based ratios for education and employment, which predominantly position computer science (CS) education and the IT industry as suitable for women. However, in many countries without government decrees, universities seem to find attraction and retention of women in IT degrees a challenging problem to solve. Drawing on Australia as an example, women undergraduates in faculties of information technology (FIT) are significantly underrepresented compared with those in other STEM areas—for example, 13% in technology compared with 22% in physics and astronomy and 35% in mathematics (Office of the Chief Scientist, 2016). There is a compelling need to investigate the problem as we do not fully understand why women in some countries do not enter undergraduate degrees, have a high attrition rate, and then either do not enter the field or remain in the field for a short time.

The main aim of this paper is to use the concept of moral imagination to examine women's underrepresentation in the CS and IT fields and to better understand what may shape the participants' choices. We first situate the study in contemporary literature and review enrolment, retention and imagined possible futures as women enter the field of CS or IT. We then discuss the theoretical framing, drawing on Vygotsky's (1987, 1997) cultural-historical approach, specifically, the concept of moral imagination put forward by Vadeboncoeur (2017) and Vadeboncoeur and Vellos (2016). This is followed by a broad overview of how the concept draws from Vygotsky's (1987, 1997) theory of learning development and Greene's (1988) concept of social imagining referred to in her philosophy of education. The current study is then presented—the method, findings and discussion.

2. Literature review and theoretical framework

2.1. Enrolment in CS and IT degrees

Since the 1970s, there has been a steady increase in bachelor's degrees awarded to women, with the exception of mathematics and computer science (Ginther, 2018) because of the underrepresentation of women in technology-based careers, gender is an equity issue that is regularly explored in CS and IT education (Murphy, 2019). There are diverse reasons provided as to why women choose not to enroll in CS or IT university degrees (Cheryan et al., 2017; Dempsey et al., 2015). With a focus on relations and relationships, this review examines personal constraints and the pathway through high school.

First, we situate the terms relations and relationships by using Vadeboncoeur's (2017) understanding, which follows the work of Marx and Engels (1970), and Smith (2005). According to Vadeboncoeur (2017), social relationships concern person to person interactions, such as the relationship between an individual and the person's parents. Vadeboncoeur (2017) discusses the term social relations as, 'the implicit patterned practices between individuals as members of a group,' (p. 173) and the way a person is positioned within a particular role. The interactions are shaped by membership in a particular category, such as a gendered category where there are implicit ways of speaking and acting that are not necessarily obvious to individuals (Vadeboncoeur, 2017). For example, a relation that is based on gender, may involve a woman in IT relating to male colleagues who see her as a woman in IT.

Second, with regard to personal constraints, studies have revealed that women's low self-efficacy and computing confidence compared with men contribute to the low enrolment in IT and specifically CS degrees (see Cheryan et al., 2017). Women tend not to believe that they can succeed in an IT-related degree (Beyer et al., 2004), and it appears that there is a gendered difference in value orientations towards such degrees. Sax et al.'s study indicates that women have a 'commitment to social activism and [a] weaker commitment to making theoretical contributions to science' (Sax et al., 2017, p. 284). These studies direct attention to the historical ways in which women engage with IT and the pathways that lead to enrolment in CS or IT degrees, which involves school systems and participation in highschool IT.

In some school systems, it appears that the skills required and used as the foundations of a scientific discipline are not readily taught (to both men and women); rather, the use and access to software and the internet hold precedence (Spieler et al., 2019). Students tend to acquire low-level skills in CS- and IT-related subjects, and may not have the opportunity to understand or learn fundamental concepts, placing them at a disadvantage prior to enrolling in a degree (Spieler et al., 2019). This supports longstanding research by Carter (2006), who surveyed 836 high-school students and found that students had limited formal experience with computing in classrooms and few understood what a CS degree involved. There were two main reasons for not entering a CS degree: first, no desire to sit in front of a computer all day and, second, another degree had already been selected (Carter, 2006). There is a need for better understanding of the specific roles of IT and CS disciplines in high-school curricula. It appears that the type of curriculum and what is delivered may contribute to women's participation in CS and IT and the low numbers of enrolment in these degrees.

Longstanding research indicates that a positive mathematics self-concept has been found to be the strongest predictor concerning the choice of women to enroll in a CS degree (Margolis et al., 2000). Yet, it appears that this is becoming less evident in more recent studies (see Sax et al., 2017). In their study of 187,717 women and men enrolled in CS degrees, Lehman et al. (2016) revealed that women tend to score lower high-school grades than men and women in other STEM fields, and rate themselves lower than men in academic and leadership ability but higher in verbal and artistic ability. In summary, from both longstanding and more recent studies, women's positive self-concept in mathematics, their high verbal ability, and personal constraints such as low confidence and differing values contribute to whether or not women enroll in a CS degree. The high-school curriculum and the emphasis on CS and IT, and how related subjects are taught in some countries, seem to contribute to the low interest and subsequent low enrolment in CS and IT degrees.

2.2. Attrition and retention of students in CS and IT degrees

There are various reasons attributed to the high attrition and low retention rate once women have enrolled in CS- or IT-related degrees. This connects with Spieler et al. (2019), who revealed that students with a basic understanding of programming concepts and experience in the field are more likely to remain in the degree than those without.

Social challenges have been identified as a contributing factor to the attrition of women in IT degrees (see Estrada et al., 2018), with extensive reporting about masculine traits, specifically, stereotypical males attracted to the field (Alfrey & Twine, 2017). The cultural understanding of the stereotypical males, known as 'geeks', includes men with a single-minded focus on technological pursuits at the expense of social interaction, emotional connections and caring for others (Thébaud & Charles, 2018). According to Alfrey and Twine (2017), the culture built around 'geeks' contributes to structural inequalities and negatively impacts women's participation. Other social constraints include women's concerns with male interpersonal communication and people skills (see Koppi et al., 2010), and the minimal opportunity for women to form relationships with their peers enrolled in a degree (see Stoilescu & McDougall, 2011). These challenges seem in opposition to what women value, such as working in collaborative and caring spaces (Thébaud & Charles, 2018), and contribute to women not completing degrees and pursuing careers in the field.

Gender studies problematise how women are positioned in relation to their participation in CS and IT and aim to dispel myths, including gender differences in preferences and performance (Berdousis & Kordaki, 2018). Other studies discuss the media influence, and ways a particular social group is represented in different forms of media (film, newspaper, social media) effects the way the group is perceived within a society (Fryberg et al., 2008). Although depictions of women in CS and IT are slowly changing, representation of women do not align with ideal role models portrayed in the media, and ways messages are manipulated and communicated can deter women's interest in the field (Cheryan et al., 2013). Adding to the media influence is the marketing of personal computers, which are consistently presented as toys specifically for men and boys (Cheryan et al., 2013). These studies suggest that the media influence positions women in astereotypical ways, and contributes to women not entering the field.

Parental influence is referred to in other studies—notably, how girls are socialised away from CS- and IT-related fields from a young age (Vekiri, 2013). By contrast, established research indicates that for males enrolled in CS majors, their computing experience begins from a young age, and they tend to gain access to their own computer or have the family computer located in their bedroom (see Margolis et al., 2000). These studies direct attention to the situation as it is; however, a deeper understanding of relational aspects is missing from this body of literature—women's perceptions of what could and should be as they form their life projects in CS and IT undergraduate degrees.

2.3. Employment in CS and IT and staying in the field

Around the world, the labour market and all social institutions reproduce persistent gender discrimination (Britwum, 2019). Studies of graduates from STEM faculties have found that inequality increases as people progress through career pathways, and there seems to be little regard for social inclusion despite companies aiming to increase the number of women and underrepresented minorities in the workforce (Estrada et al., 2018). Coupled with the underrepresentation of women in the field, those women who are employed tend to be in the lowest paying positions (Lim, 2016). Lehman et al. (2016) found that men were significantly more likely than women to be interested in pursuing employment as a computer programmer and women were significantly more likely than men to be undecided about their career choice (Lehman et al., 2016). Similar to Carter's (2006) study in high schools, neither men nor women fully understood the type of work completed in the CS industry and many were unable to explain what type of work a computer scientist engaged with when in the field. This substantiates research claiming that the CS industry has not been well understood or marketed in an accessible way to the general public (Cassel, 2011). Missing here is an understanding of what could be—that is, the way technology is changing and is interdisciplinary. Today, programming backgrounds are required in many fields (Cassel, 2011).

The majority of studies reported here are quantitative, based on empirical research in which the theoretical understanding is hidden in everyday assumptions underlying the research questions. There are few studies 'presenting the complex interplay of forces that affect women's decisions' (Singh et al., 2007, p. 518). Therefore, our current knowledge is limited to everyday understandings and we need a stronger basis for conceptualising this important issue.

2.4. Positioning the current study

The challenge needs to be understood from the historical, cultural and social context—from the women's own relational understanding and experience—to better understand women's choices. This may result in a need to move away from each woman's capacity to conform to the current cultural and social dimensions to better understand the strengths and new perspectives that women can offer. When discussing education, Stetsenko (2017) argued that today's systems require a complete reconceptualisation because of the inequalities and disparity that are evident; this seems equally pertinent for the CS and IT field. It is through a transformative lens and critical engagement with theory that such a critique is possible (Stetsenko, 2017). Therefore, we use theory to pose the following research questions and contribute to understanding the challenges surrounding the low uptake of women in FIT degrees:

- How do women understand the situation as it is, could be and should be in the field of CS and IT?
- What relational sensibilities contribute to women's attraction and retention in the field?

To address some of the complexities, listening to women's experiences of the situation as it is, could be and should be as potential

life projects are formulated in relation to, and with, others as they engage with IT undergraduate degrees becomes a main focus. As women have been underrepresented in the IT field for decades, we argue that there is a need to understand the women's historical, current and future directed perceptions, situated within their current social context. To do this, the cultural-historical concept of moral imagination is drawn upon and now explained.

2.5. Moral imagination and cultural-historical theory

Moral imagining, or the moral imagination, is a cultural-historical concept, that is best described in Vadeboncoeur (2017), 'how we create relationships with each other, how we see ourselves in relation, how we value our relatedness, and, ultimately, what it means to us to become a person in relation' (p. 266). From this point of view because imagining is a recombination of the past in the present to create future oriented actions, considerations of what is, could be, ought to be is by definition moral action. The current study has its focus on how the moral imagining of the participants may shape their career choices and direct attention towards a more equitable social future for women in IT. Using a cultural-historical theoretical framework, we argue that moral imagination is strongly positioned in learning and developmental processes founded on relational support (Vadeboncoeur, 2017; Vygotsky, 1997). The moral imagining was developed 1) from "seeing" each other in relation, 2) recognizing each other as changing/developing, and 3) acknowledging the ways in which relating in the present shapes the social future of the participants (Vadeboncoeur & Vellos, 2016). Imagination is a powerful tool in this process as it provides a way to move forward.

Although imagination is not often recognised in the everyday life of adults—apart from through art-based activities—imagination *is* present when linking the past, present and future together (Greene, 2011; Vadeboncoeur et al., 2016; Vygotsky, 2004). When understood in a conceptual way, imagination provides a means to move beyond deficit views of everyday life (Greene, 2010) to change a situation (Vygotsky, 2004) and incorporate thoughts and actions that transform static views of communities into democratic, inclusive ones (Dewey, 1916). Here, we look towards imagination to address the tension directed towards transforming futures of women in IT. From the review of the literature concerning women in CS and IT, there is a unanimous agreement concerning the urgent need to *change* women's low participation in IT.

The ability to imagine situations, to enact initiatives and intentions, in order to change the deficit view held within society can be achieved through reflection, planning, joint actions and advocacy. Imagining prevails when people are inspired to 'move away from the ordinary, to look at things as if they could be,… might be, should be otherwise' (Greene, 2010, p. 1). Vadeboncoeur (2017) agreed and merged Greene's concept of social imagining with Vygotsky's understanding of imagination. In Vygotsky's theory, imagination is understood as imitation, not the everyday understanding in relation to copying but at a conceptual level where, through imagination, a situation is reworked and understood in a new and different way (Vygotsky, 2004). Imagination goes beyond what an everyday experience accepts as 'normal' to provoke different ways of thinking, feeling and then acting (Britzman, 1998).

Vygotsky (2004) advocated the use of imagination as a way to form a zone of proximal development to support movement beyond the person's actual level of development to extend their thinking, feelings and actions in relation to a specific historical, cultural and social setting. In a similar way, Greene (2000) suggested that people may require support to understand the surrounding culture, and to name what is lacking, and to identify what could be done in an effort to transform the situation. The use of imagination helps us to learn and alter our cultural tools (such as language used) in response to changing conditions that provide opportunities, 'to think beyond cultural norms and expectations, [and] also results in the creation of new relationships and, thus, possibilities for new selves' (Vadeboncoeur, 2017, p. 262). Important to this understanding of the moral imagination is 'relational sensibilities' that are possible, as a result of a relationship, for example, opportunities that are expanded or transformed, and the encouragement offered therefore, moral imagining as a 'relational sensibility', occurs in a relationship (Vadeboncoeur, 2017). Learning first with others and being able to apply the learning to new and different situations enables possibilities for a conceptual leap in understanding, for transformation at a cultural and social level—the type of thinking and acting required to increase the participation of women in IT. There is a need to be proactive and move beyond purely experiencing the world—to contribute actively to its co-creation as a 'collective practice and an agent of communal history' (Stetsenko, 2017, p. 34). Imagination can be used to design learning opportunities and merged with reality to inform learning communities that inspire ways in which more women could be introduced and take up opportunities to engage in the field of IT. However, it is important to recognise that depending on the context, moral actions and understandings will vary depending on each person's perspective.

The concept of moral imagination has recently been applied in studies relating to re-imagining education and providing interconnected learning opportunities across varying contexts (Vadeboncoeur et al., 2014). It has been further extended when examining relationships between students and teachers with the aim of re-engaging students in alternative education settings and building together alternative social futures (Vadeboncoeur & Padilla-Petry, 2017; Vadeboncoeur & Vellos, 2016). These studies highlighted the potential application of moral imagination for the current research when analysing women's experience and possible futures in the field of IT.

3. Study methodology

The data presented here form part of a larger research project that explores the retention and attrition of women undergraduate students enrolled in FIT degrees at a high-ranking university in Australia. The participants' ideas of the situation as it is, could be and should be in relationships and relations, and the importance of these for their possible life projects in the IT field, were examined. We analysed 12 women participants' past and present experiences through the lens of moral imagining, and visualised how they imagine their potential futures in the field of IT to look like.

Table 1
Participants in the individual interviews and focus group.

Individual interview participants				
Name	Anna	Bren	Cat	Ina	Sue
Study focus	Computer Science	Computer Science advanced	Computer Science and Commerce	Software Engineering	Computer Science and Education

Focus Group participants						
Name	FGAnn	FGBron	FGKath	FGLee	FGSarah	FGTalia	FGFiona
Study focus	Computer Science	Computer Science advanced	Computer Science and Commerce	Computer Science	Education and Computer Science	Computer Science and IT	Computer Science and Education

3.1. Participants and selection

The current study was undertaken at a university located in a southern Australian city. On receiving permission from the university ethics committee, and in line with the ethical protocols, participants were initially recruited via bulk email with a link forwarded by FIT professional staff to all 201 female students enrolled in the undergraduate CS degree. The women were invited to contact the researchers if they were interested in participating in the study. Prior to the interviews and focus group, students were forwarded an explanatory statement and consent form. Participants were invited to sign and return the consent form either by email or by placing the form in a sealed box on exit from the semi-structured interview or focus group because of the vast quantity of data collected, only selected parts of the individual interviews and *focus group* are presented here. The women whose data are presented are briefly introduced (see Table 1).

3.2. Development of the semi-structured interview and focus group questions

The semi-structured interview questions were piloted with FIT volunteers to ensure 'reasonably unbiased data' yield (Gall et al., 2007, p. 251). During the pilot interviews, the researchers focused on areas that had the potential to create confusion, including the logical flow of procedure, the need to rephrase questions because of the possibility of different interpretations to the same question, and questions that may cause discomfort (Wiersma & Jurs, 2009). There were four questions modified for clarity during this process.

To maintain collection of a standard dataset, the same semi-structured interview questions were used to initiate conversation in the individual face-to-face interviews and the focus group. The interview questions were divided into categories; representative examples are provided:

1. Pre-course factors

- Why did you choose to study in this particular degree?
- How could more women be attracted to enroll in the same degree?

2. Course

- What are the benefits of being enrolled in the degree?
- What are the challenges of being enrolled in the degree?

3. Future engagement

- What role do you envisage for yourself in the field of IT?

The questions aligned with the cultural-historical theoretical framing of what is, could be and ought to be (Vadeboncoeur, 2017).

3.3. Training the interviewers

There were two interviewers; one was experienced in qualitative interviews and the other was trained in the procedure during the piloting phase of the interviews. To maintain validity across the dataset, the same two interviewers were present at each semi-structured interview and during the focus group. The experienced interviewer was not part of the CS field, while the trainee interviewer worked in the field and had substantial knowledge of the field. According to Gall et al. (2007), selection of an interviewer connected with or from the target population supports building rapport with the participants, and is an important consideration in qualitative research.

3.4. Generation of data

There were five semi-structured interview participants and seven participants in the focus group ($n = 12$). Participants were purposively selected (Gall et al., 2007) as each person was enrolled in an undergraduate degree in the FIT. The five semi-structured interviews lasted for approximately 1 h each ($n = 5$ h), and the focus group lasted for 2 h (yielding a total of 7 h of data collection).

3.4.1. Semi-structured interview

The discussion during the one-on-one interview was initially based on a series of structured questions. After each question was answered, the interviewer asked open-ended questions to probe more deeply for additional information relating to the participant's experience with regard to deciding on a degree, during the degree and their possible future in the field. This type of data collection has the advantage of obtaining standard data for each participant, and provides more depth of detail than a structured interview (Gall et al., 2007).

3.4.2. Focus group

The discussion was initially based on each individual's experience in selection and remaining in an FIT degree and possible future

choices after graduation. Wiersma and Jurs (2009) suggested that there should be seven to ten participants in a focus group, and participants need to be well informed about the topic. The focus group was held because of the way 'interactions among participants stimulate them to state feelings, perceptions, and beliefs that they would not express if interviewed individually' (Gall et al., 2007, p. 245). The social interactions among participants were an important focus in the exchange, referred to as collaborative dialogue (Hviid, 2008). The environment was comfortable; the focus group was relaxed, and the women were open about their experiences and responded to each other's ideas and comments, building and elaborating on each other's anecdotes concerning their personal experiences, before enrolment, during the course of the degree and regarding potential life projects after graduation.

Validity of qualitative research may cause challenges as it can be difficult to replicate studies, particularly when they occur in naturalistic settings (Wiersma & Jurs, 2009). In the current research, validity was established through documenting each step of the research methodology, including training the interviewers; piloting the questions; and having the same two people present during the semi-structured interviews, focus group and analysis process (Gall et al., 2007).

3.4.3. Transcripts

In line with ethical and participant permission, the semi-structured interviews and focus groups were audio-recorded and transcribed verbatim. Conventions followed included naming the research data, attributing a code and pseudonym to each participant, listing the date and time of the recording, outlining the setting and noting the duration of the interview (Jenks, 2011). This was followed by logging the transcript and producing a table of contents. These processes were used for easy access and interpretation of the datasets for the analysis. The process of transcription enabled analysis of the women's collective awareness of the situation as it is, could be and should be.

3.5. Analysis

The analysis of the interviews and focus group incorporated a three-stage iterative process (Hedegaard & Fleer, 2008) where the content of the discussion and the social constructions in the dialogue were the focus of the analyses (Hviid, 2008). Hedegaard and Fleer's (2008) three-stage approach to data interpretation was applied. Initially, a *common sense* interpretation was sought, with the relevant contextual information extracted from the data; this included each participant's background, degree and education level. The next stage was *situated practice* analysis, where situations across settings and time frames were analysed, including the participants' introduction to IT; school experience in relation to IT; current thoughts, feelings and actions; and ideas regarding the type of futures they envisioned when working in IT. The final phase was directed towards the *theoretical analyses*, where the participants' references to their past, present and future in relation to IT and within society as a whole were considered. We directed analyses to moments of 'unconcealment' that initiated discussions about a variety of experiences and future imaginings (Greene, 2010, p. 1).

4. Results

The results of the study will be presented in two phases. First, we highlight ways in which the women linked their past experience with their present experience—what is. Second, we discuss what the women imagined—what could be and ought to be—as they positioned themselves in the field of IT. The overall focus is on implications drawn from the analysis regarding how to change future directed practices and ways to support women to enter and remain in the field of IT.

4.1. The past: interest in CS or IT

Extending other studies of women in IT (see Sax et al., 2017), only some of the women in the current study indicated that their initial interest stemmed from having a family member or teacher who encouraged their involvement in IT (Cat, Fi, Ina). The parents and teacher were able to 'see' the strengths, desires, and interests of the participants. All of the participants from the interviews and focus group indicated that they did not have formal training but a general interest in IT. Their interest was initiated and sustained as they had access to a laptop and were challenged by a need to solve a particular problem with coding. Once the women realised that they could solve the problem by themselves with the use of self-study sought on the internet, their interest was sustained and grew. The women were able to see the strengths that were developing in themselves. This interest and knowledge were affirmed by others as the women shared what they were able to achieve, and were told by others that they were 'good at IT' and hence seen by others. The women's own interest, combined with their positioning by others, led to more opportunities to improve their skills, gain confidence in their abilities, and help others to work more with computers and programming, and then enter an FIT degree.

There are similarities to studies where boys and men have access to and develop a self-sustained interest in CS from a young age, directing their futures towards CS or IT (see Margolis et al., 2000). Different from current literature was the way in which the women's context was found to support their self-directed learning through access to laptops, where they spent time to develop their interests. The women communicated their expertise and new-found skills to others, they were able see their own strengths that were developing. In addition, the social connectedness for the women in the current study was found to be important as they developed an interest in programming; however, there was movement beyond this. The women's emerging relational sensibility began to shape their developing perceptions and actions specific to who they were becoming while forming relationships and who they saw themselves as in relation to other social and cultural groups (Vadeboncoeur, 2017). The significant others were able to understand the women as they were developing their confidence and skills. The women's relational sensibilities and the importance of 'seeing' women and being 'seen' by other women (and significant others), contributes to an emerging social future and potential pathway into the field of CS or

IT.

4.2. Social aspects

Social aspects included the women's concerns with interpersonal communication and people skills (see Koppi et al., 2010), and the lack of opportunity for women to form relationships with their peers (see Stoilescu & McDougall, 2011). Providing a different perspective, according to the participants in the current study, young women and girls tended to place importance on continuity of relationships with their peers. Friends were a major consideration when deciding on whether to enter the field of CS or IT. Representative examples discussed in the focus group and interviews follow:

There is definitely that interest [in IT] at that tweenage level—it gets killed. (FGTalia)

I think the biggest factor is having your friends doing it. (FGFiona)

When I say [to other women students not enrolled in IT], 'I'm doing computer science', quite a few girls say, 'Oh yeah, I enjoyed that when I was about 13'. [I ask], 'Why aren't you studying now?' [They reply], 'Oh, none of my friends are doing it and I didn't want to do it anymore'. (FGBron)

In the interviews and focus group, the participants discussed how their friends lost interest in IT during the 'tweenage' years and that other women, when questioned why they did not continue with their interest, stated it was because their friends did not persist. The underrepresentation of women has been related to social, individual, structural and cultural dimensions located within societies (Cozza, 2008). Few studies have investigated the importance of affective connections within social relations and their importance to women as they decide on a CS or IT degree. Key to social relations are emotions and imagination—how experiences are interpreted, which is informed by and informs conceptual understandings of the experiences (Vygotsky, 1987). Affect and building relations are opposite to perceived requirements in the field of IT, particularly the stereotypical 'geek' discussed by Alfrey and Twine (2017), who is attracted to clinical, individual work in social isolation. The women in the current study did not accept the status quo and were able to consider alternatives rather than follow their peers. When thinking about performing a particular role, moral imagination supports considering choices (Vadeboncoeur, 2017). Being open to and considering alternatives during their teenage years enabled the women to enroll in an undergraduate degree in the FIT.

4.3. Recognition of past/current positioning

The focus group discussion revealed that the women participants were conscious of their own self-perceptions, and their self/other positioning from a young age. As adults, there was a collective feeling against putting themselves forward and overstating their achievements in IT:

It all started when you were in your mother's arms and she was cradling you and whispering to you. (FGAnn)

It's hard because you have kind of been socially trained to talk yourself down and then you are trying to untrain. (FGTalia)

A lot of girls probably don't even realise that's how they think. (FGFiona)

It's the Tall Poppy Syndrome*, where you don't want to talk yourself up. (FGAnn)

(*Tall Poppy Syndrome is a term used in Australia and New Zealand to describe a social phenomenon in which people of merit are resented or criticised because their achievements or talent elevate them above others.)

I wouldn't have noticed how much we talk ourselves down if I didn't do an interview with another guy who was talking himself up … I wouldn't have known otherwise how bad it was. He said all this stuff like he had all this experience and was an expert in programming but I know for a fact he's not as good as he said—I helped him finish the job. (FGBron)

We do sometimes undersell ourselves and we should try and get out of that mentality but the thing is it's not just something you can pop on a lecture site and go don't undersell yourself. (FGTalia)

I think it is the internal psych that just keeps coming out … you need to switch off. (FGFiona)

Whatever you are hesitating about stop—just, just do it, just do it. (FGTalia)

From the focus group discussion, the women indicated that identifying themselves in relation to others begins from birth and becomes part of an internal conversation ('socially trained to talk yourself down'), which in turn presents as a particular form of social positioning that may not be conscious to some ('girls … don't even realise that is how they think'). The women indicated that this positioning is challenging to move away from ('you are trying to untrain' and 'you don't want to talk yourself up') particularly when men tend to inflate their own experience ('talking himself up'). Their realisation of the need to be more positive turned to collaborative talk about ways to move forward ('stop hesitating—just … do it, just do it').

In line with other studies (Lehman et al., 2016; Sax et al., 2017), it was revealed here that the women seemed to have a low self-assessment in their own ability compared with that of men in IT. The women in the current study attributed their low self assessment to socially structured positioning from a young age, and the societal constructs around the 'tall poppy syndrome' which links directly to the 'imposter syndrome' where the women indicate they do not feel 'good enough' to enter the field. The 'imposter syndrome', is understood when the women, despite their successes, voice their concerns and feelings of inadequacy. It is interesting to note that this is an individual and a collective feeling of inadequacy as they embark on a career in CS or IT fields. Linking to the moral imagination, the participants are not wanting to be 'seen' and cease to 'see' in themselves their strengths and potential to change the situation. Yet, they see others without the required skill set putting themselves forward with confidence. The discussion gives insight into the women's collective feelings, and the way the women were keen to learn about the self and then apply the learning, and change perceptions of the self, which required transformation. A conceptual leap in understanding is required when learning with others, which then shifts to become conscious for the individual (Vygotsky, 1987). The women in the current study recognised the need to be

proactive both individually and collectively to move beyond experiencing their world in IT—and work together to contribute actively and co-create new understandings to transform the world for themselves and others (Stetsenko, 2017).

Transformation as the women entered a degree in IT seemed to encompass the women becoming conscious of their own positioning and enactment of a particular role. *Re*-learning ways to position themselves without talking 'yourselves up' created emotional tension between their current and emerging identities. As the women discussed new directions—moving from the known to the unknown, from the familiar to the unfamiliar—and the need to change, it contributed to the process of transformation. Through the focus group, it appeared that the women were transforming to consider a 'relational disposition' (Vadeboncoeur, 2017, p. 265), that is, inquiring and questioning current ways of thinking, feeling and acting through developing their ideas of a socially just world of what is and what is not acceptable in relation to their own and each other's relational sensibilities.

4.4. Current positioning by others enrolled in the degree

Differences between men and women when reporting on self-efficacy, enacting interpersonal orientations, values and interests are well documented in the IT literature (Beyer, 2014). The participants discussions revealed minimal adherence to social norms by some male colleagues in FIT cohorts, which caused concern. Cat revealed the following in her interview:

I have heard of some male student not being aware of social norms. I don't think any of them mean it maliciously … but the way they come off might be off putting to some people and might deter say women from attending consultations from asking questions.

This was further reiterated by the following comments in the focus group:

The mentality of the rest of the cohort especially the guys is a big issue. (FGTalia)

It's not something that's said, it's something that you feel … it's not that they are all saying explicitly, 'Oh, men are better'. It's just that they will treat you differently … you could say that socially in any situation there are gender differences … but in terms of being constantly surrounded by men—males who will kind of undermine your opinion or not treat you properly … it's something felt, it's really hard to explain … I mean you can't blame someone for not understanding … it should just come as mutual…. My experiences should not be erased because you yourself cannot comprehend them. (Bren)

The amount of times you are sitting in a lab and you ask the guy next to you—I can't remember the syntax … or whatever and they are like oh let me help you I will help you do this. It's like I know how to code—I have forgotten this *one* thing. (FGFiona)

Over the course of a degree, all students require a variety of support from their peers and teacher educators, based on their everyday experiences, as 'developing is the process of becoming a social individual and being in relation comes with moral implications' (Vadeboncoeur, 2017, p. 273). Moral implications direct attention to social attitudes and gendered expectations, of what is deemed right or wrong depending on the person's perception of the experience. It seems that the women in the current study perceived that they had different experiences to those of the men enrolled in the degree. The women felt *as if* they were positioned as someone who does not know the full depth of the answer, rather than someone who has forgotten a small portion of the coding system. According to Bren, the attitude of men, combined with the reported low awareness of the women's expected ways of interacting, created tensions and challenges for some women in the study. For Bren, the social interactions appeared challenging to put into words as she felt that women were undermined and their experiences not understood by some male colleagues. The women felt as if they were not being seen as enacting or participating at the same level as their male colleagues. This highlights a gendered difference in value orientations and may contribute towards womens' low participation in the field, as according to Beyer et al. (2004), belief that a person can succeed in the field is important to that person remaining in the field.

4.5. Recognition of current/future possibilities

Disturbingly, many students (males and females) cannot define what an IT career involves (Croasdell et al., 2011; Lehman et al., 2016). Discussions with the participants in the current study revealed that there was no clarity around a career in CS or IT and few career pathways were explained or obvious to those enrolled in an undergraduate degree; this included when advice was sought. Representative examples from participants' interviews explaining their point of view follow:

There are things that are clearer. I mean people would be, 'Oh, I'm more inclined to do law or medicine just because they're things what I'm familiar with'. Even if IT is secure, if you're unfamiliar with that—you're going to be less inclined to take it. (Bren).

It's really interesting and I'm still learning … I don't really know much about what's out there. (Ina)

Similarly, Cat and Anna indicated that they had little ambition and were uncertain of available career options, and when specific career advice was sought in relation to the CS or IT professions, general advice was provided:

I don't really have much ambition at the moment. I'm not sure what I really want to do after Uni … job wise, career aspirations wise I don't really have much direction. (Cat)

I'm not sure of where I could go to talk to people about career advice and things like that. I have gone to a career workshop but I don't think they were in the position to really guide me towards any specific field or any ideas about any specific career [in IT]. They just gave me some valuable advice about … a social media profile and building up a network. (Anna)

In combination, the uncertain knowledge of what a career in IT might entail, and the barriers to access information about opportunities in the field of IT, may contribute to the low retention rates of women graduates because of unimagined futures in IT. Moral imagination seems to be missing as the compass for self-direction (Vadeboncoeur, 2017). Self-direction seems to be an autonomous pursuit where the learner takes responsibility for their own learning, and is determined by characteristics of personality. Recognition of the way social learning supports this process, that is, the interdependence between people as they learn (Vygotsky, 1987), cannot be overlooked. In this instance, the women undergraduate students enrolled in IT degrees and those who guide them towards their future

life projects, beginning in early childhood, all contribute. These challenges when drawn together may discourage women from studying IT and instead may contribute to directing the women to a less ambiguous career path.

5. Discussion and conclusion

5.1. Social past of women in IT

The historical heterogeneity of the IT field has led to the development of inherent structural organisations, belief systems and policies (Margolis et al., 2015), which contribute to constraints placed on women in their journey to enter the field. Opportunities for learning occur in and across a variety of contexts, and are situated historically, culturally and socially, beginning in the family and continuing in societal institutions. Learning is a process that occurs over time and contributes to development of thinking, enacting and relating, particularly the type of learning that the women in this study allude to—which is affected by social positioning.

The types of social learning about cultural forms of knowledge, and being identified and seen with and as a particular kind of person, are valued and socially meaningful (Vadeboncoeur et al., 2014), and further reiterated as women move through societal institutions. It appears that these structures— inherent not only in the field of IT but also more broadly in society as a whole—are evident *prior to women entering* the field of IT. Interaction is learned through social participation within families and then reinforced through engagement with institutions outside the family—in this instance, it is the social interaction where women learn to 'talk yourself down', where they position themselves to not be seen and discuss the 'Tall Poppy Syndrome'. The unconscious way that girls and women engage with and enact these conversations from a young age creates a powerful cultural tool that is challenging for some women to move away from—to relearn, transform and imagine a different way of participating as a woman in the field of IT as their identity and emerging relational sensibilities develop.

The participants in the study reflected on girls during their teenage years and, as Vadeboncoeur (2017) reminded us, the importance placed on emerging relational sensibilities—that is, who girls are as members of a social group, which is part of their emerging identities and who they are in relations. For the women in this study, the importance of sustaining relationships was held in high regard. This aspect is not often recognised as important in the literature in relation to the field of IT. Further, belonging to an underrepresented group, having others who are like minded and role models, and colleagues continuing in the fields is valuable in positioning the self in relation to emerging identities. Vygotsky (1987) put forward the argument that we learn first from others in our social environment, and then as we understand at an abstract or more conceptual level, we are able to make conscious our own understanding to support others in their learning. For the women in the current study, it seems that self-directed learning about problem-solving in IT, with support located on the internet, was sufficient to initiate an interest in IT. The moral imagining across everyday life contributed to sustaining and creating continuity of relationships as they participated in problem-solving, initially for themselves and then for and with others as confidence was gained in their IT skills. The women participated in new and different ways to initiate, learn about and sustain their interest in IT. As the women's knowledge and expertise in IT developed, it was the interaction and positioning as knowledgeable in relation to others (Vygotsky, 1987) that contributed to sustaining and imagining that there may be a future in IT. Imagining moved to reality as they enrolled in an IT degree.

The change over time as they became known by family and friends as the 'go-to person' for IT challenges directs attention to the process of learning, the way in which their learning was jointly constructed and valued by others. Learning how to solve problems created a system of meaning making (Vygotsky, 1987) for the women as they taught themselves how to solve problems and continued to jointly construct processes where others who were significant in their lives were included. This process may be described as the 'dynamic learning, unlearning and transforming of how we create social relationships with others,… how we value our relatedness' (Vadeboncoeur & Vellos, 2016, p. 308). For the women in this study, problem-solving, emerging self-positioning and recognition of the positioning of others supported the women's continued interest in the field.

Rowan and Lynch (2011) suggested that attempts to increase female participation in IT need to be initiated in teacher education, specifically in areas that challenge common socialisation and explanations of girls' behaviour. However, this imagining and creating of new practices (Vadeboncoeur et al., 2016) needs to extend beyond teachers only to the whole community to effect changes and develop projects that encompass respectful relationships and what they might look like across a society. This, according to Greene (1988), includes initiatives to change the continuity in relation to women's current self-positioning and positioning by others from a very young age and through life's course.

5.2. Current social presence of women in IT

There are learning and developmental processes that contribute to continuity and change, which can have a both a progressive and alternatively, regressive outcomes (Vadeboncoeur, 2019) and need to be considered in the field of IT. The women in the focus group decided that they needed to change their current self-assessment and self-positioning—potentially a progressive outcome.

This may be perceived as a legitimate way to move ahead for some women in the field of IT; however, it is not necessarily the only way. For some, it may seem like a regressive outcome that reinforces the current culture within the field but does not necessarily add to an imagined change in culture or relations. As Vygotsky (1987) pointed out, each person shapes and is shaped by their environment, which is a source of development. This is important for the development of women entering the field of IT as recognition of the women's own developmental trajectory—which includes their identity, capabilities and contribution to the field—and being open to new challenges are required. Recognition that women can and do contribute to their environment needs to become standard practice so that they contribute to changing the historical and current ways of being identified with and as a particular group to be empowered

and to set their own agenda of how they want to be perceived and included in the field of IT. As Margolis and Fisher (2002) stated, 'the goal *is not* to fit women into [IT] as it is currently taught and conceived' (p. 6) but a transformation of the culture so that women's opinions and contributions are respected, valued and enacted.

A related theme discussed by the women in the current study was that their experiences were not validated or necessarily understood by male members of their cohort. This is a repeated regressive outcome in the literature (Stoilescu & McDougall, 2011). The participants in the current study indicated that some male members in the cohort do not experience or understand the implicit practices that they engage with in relation to women enrolled in degrees. It has been found that male students enrolled in CS degrees have an insufficient exposure to and understanding of social issues (Stoilescu & McDougall, 2011). This is with regard to not only recognition of the way women contribute to and shape the IT environment, but also recognizing the contribution and the shaping of the environment by others. This type of thinking requires an understanding of the importance of affect and its unity with conceptual understanding (Vygotsky, 1987). This may manifest as the ability to experience our own feelings and those of others by imagining and interpreting the meaning of a situation—as Bren stated, 'My experiences should not be erased because you yourself cannot comprehend them'. We need to progress to make what is said, what is enacted and the perceived expectations visible when acting in relations. Drawing the discussion together directs attention to the need to *educate communities* in relation to respectful relationships and what these might look like, initiating a way to imagine a different future in IT.

5.3. Imagined social futures of women in IT

The moral imagination is a future directed act. We need to enable thinking about things that have existed and things that are in process and yet to exist (Vygotsky, 2004). Our past shapes the future and the present; yet, 'it is the moral imagination that creates a desire for and gives direction to life's on-going projects' (Vadeboncoeur, 2017, p. 272). At this stage, for the women in the study, their ongoing projects include a future in IT. Although adept at working with IT, some women appear to find it challenging to imagine their future *in* IT because of the limited accessible information and their personal aspirations of what is available on completion of their degree.

Throughout the discussion, the women's compass for self-direction and action changed in terms of the need to create and transform not only relationships with themselves and others but also ways to change the culture. The historical and current positioning by others contribute to the women's self-positioning. From the women's perspective, progressive outcomes are indicated where the women want to change; however, this cannot be achieved in small groups or isolation. Moving from imagined and possible outcomes to expected and enacted futures in IT includes male and female role models, teachers and career advisers who are informed and understand career paths in CS and IT.

5.4. Concluding remarks and implications for the field of IT

As a final word, a central goal for the CS and IT fields is to provide opportunities for imagining, creating, transforming and then enacting a different culture beyond the one that exists in its current form. This would provide a potential move away from the current social issues, concerns and inequities highlights a need to engage with moral imagination. Cultural and curricular changes (Margolis & Fisher, 2002) that include a working understanding of, and responding to and enacting, respectful relationships that are introduced on a large scale are required in society and indeed within the field of IT.

The changes need to move beyond responsibility placed on one group in society, such as teachers, to include all—families, schools, universities, communities and workplaces. There is an emerging pathway that is beginning to address some of the issues of women in the CS and IT fields. These include the introduction of Australian government funded STEM programmes into preschools and primary schools, and recognition that changes need to be introduced at the tertiary level. Originating from our findings there are three implications outlined. First, in the tertiary sector, there should be increased exposure for all to understand women's past and present contribution of women leaders in the field. Second, universities should provide a space where women and girls of all ages can come together to share their passion for the field (Dasgupta & Stout, 2014), and then showcase contributions at community events and via social media. Coming together for women in the field should be a long term proposition, where women employed in the CS and IT industry mentor women enrolled in FIT degrees, who in turn mentor highschool students, all the way to early childhood. Dasgupta (2011) argues that exposure to female role models and peers supports womens' sense of belonging in the field and acts as a 'social vaccine'. Finally, universities should recruit career advisors who understand and are knowledgeable in the CS and IT fields and are able to move beyond providing advice that is limited to initiating networking through social media channels.

Forming a visible pathway would support girls and women's social futures as they enter the field, they would be able to 'see' the work of others, and be 'seen' contributing to the CS and IT fields. The extensive use of IT in our everyday lives suggests that this required access to transform women's participation in the field on a large scale is indeed possible.

Declaration of competing interest

None.

more women to become involved with the IT field.

References

Alfrey, L., & Twine, F. (2017). Gender-fluid geek girls: Negotiating inequality regimes in the tech industry. *Gender & Society, 31*, 28–50.

Aspray, W. (2016). *Participation in computing: The National Science Foundation's expansionary programs. Cham.* Springer.

Berdousis, I., & Kordaki, M. (2018). Computing and STEM in Greek tertiary education: Gender representation of faculty members during the decade 2003–2013. *Gender and Education, 30*(1), 1–21. https://doi.org/10.1080/09540253.2016.1156653.

Beyer, S. (2014). Why are women underrepresented in computer science? Gender differences in stereotypes, self-efficacy, values, and interests and predictors of future CS course-taking and grades. *Computer Science Education, 24*, 153–192. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/08993408.2014.963363.

Beyer, S., Rynes, K., & Haller, S. (2004). Deterrents to women taking computer science courses. *IEEE Technology and Society Magazine, 23*(1), 21–28. https://doi.org/10.1109/MTAS.2004.1273468.

Britwum, A. (2019). Women's future at work: Gender and equality in the Ghanaian informal economy. *International Journal of Labour Research, 9*(1), 195–213.

Britzman, D. (1998). On doing something more. In W. Ayers, & J. L. Miller (Eds.), *A light in dark times: Maxine Greene and the unfinished conversation* (pp. 159–169). New York, NY: Teachers College, Columbia University.

Carter, L. (2006). Why students with an apparent aptitude for computer science don't choose to major in computer science. *ACM. SIGCSE Bulletin, 38*(1), 27–31. https://doi.org/10.1145/1124706.1121352.

Cassel, L. N. (2011). Interdisciplinary computing is the answer. *ACM Inroads, 2*, 4–6.

Cheryan, S., Plaut, V. C., Handron, C., & Hudson, L. (2013). The stereotypical computer scientist: Gendered media representations as a barrier to inclusion for women. *Sex Roles, 69*, 58–71. https://doi.org/10.1007/s11199-013-0296-x.

Cheryan, S., Ziegler, S. A., Montoya, A. K., & Jiang, L. (2017). Why are some STEM fields more gender balanced than others? *Psychological Bulletin, 143*, 1–35. https://doi.org/10.1037/bul0000052.

Cozza, M. (2008). Narratives on platform: Stories for women in computer science. *International Journal of Continuing Engineering Education and Life-Long Learning, 18*, 97–213.

Croasdell, D., McLeod, A., & Simkin, M. G. (2011). Why don't more women major in information systems? *Information Technology & People, 24*, 158–183. https://doi.org/10.1108/09593841111137340.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychological Inquiry, 22*, 231–246.

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights From the Behavioral and Brain Sciences, 1*(1), 21–29. https://doi.org/10.1177/2372732214549471.

Dempsey, J., Snodgrass, R. T., Kishi, I., & Titcomb, A. (2015). The emerging role of self-perception in student intentions. In *Proceedings of the 46th ACM technical symposium on computer science education* (pp. 108–113). New York, NY: ACM.

Dewey, J. (1916). *Democracy and education.* New York, NY: Macmillan.

Estrada, M., Ero-Reveles, A., & Matsui, J. (2018). The influence of affirming kindness and community on broadening participation in STEM career pathways. *Social Issues and Policy Review, 12*, 258–297.

Fryberg, S., Markus, H. R., Oyserman, D., & Stone, J. M. (2008). Of warrior chiefs and Indian princesses: The psychological consequences of American Indian mascots on American Indians. *Basic and Applied Social Psychology, 30*, 208–218. https://doi.org/10.1080/01973530802375003.

Gall, D., Gall, J., & Borg, W. (2007). *Educational research: An introduction.* Boston, MA: Pearson Education.

Ginther, D. K. (2018). Why do women leave computer science and information technology jobs?. In *Presentation at the Australian gender economics workshop*. Retrieved from http://bcec.edu.au/assets/AGEW-2018_Donna-K-Ginther-Why-do-Women-Leave-Computer-Science-and-Information-Technology-Jobs.pdf.

Greene, M. (1988). *The dialectic of freedom.* New York, NY: Teachers College Press.

Greene, M. (2000). Imagining futures: The public school and possibility. *Journal of Curriculum Studies, 32*, 267–280. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/002202700182754.

Greene, M. (2010). Prologue to art, social imagination and action. *Journal of Educational Controversy, 5*(1), 1–2. Retrieved from https://cedar.wwu.edu/jec/vol5/iss1/2.

Greene, M. (2011). Releasing the imagination. *Drama Australia Journal, 34*, 1–9. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/14452294.2011.11649524.

Gupta, N. (2012). Women undergraduates in engineering education in India: A study of growing participation. *Gender, Technology and Development, 16*, 153–176. https://doi.org/10.1177/097185241201600202.

Hedegaard, M., & Fleer, M. (2008). *Studying children: A cultural-historical approach.* New York, NY: Open University Press.

Hoffmann, E. M. (2010). Women in computer science in Afghanistan. In S. Booth, S. Goodman, & G. Kirkup (Eds.), *Gender differences in learning and working with technology: Social constructs and cultural contexts* (pp. 48–64). Hershey, PA: IGI Global.

Hviid, P. (2008). Interviewing using a cultural-historical approach. In M. Hedegaard, M. Fleer, J. Bang, & P. Hviid (Eds.), *Studying children: A cultural-historical approach* (pp. 138–156). New York, NY: Open University Press.

Jenks, C. J. (2011). *Transcribing talk and interaction.* Amsterdam/Philadelphia: John Benjamins Publishing.

Koppi, T., Sheard, J., Naghdy, F., Edwards, S. L., & Brookes, W. (2010). Towards a gender inclusive information and communications technology curriculum: A perspective from graduates in the workforce. *Computer Science Education, 20*, 265–282. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/08993408.2010.527686.

Lehman, K., Sax, L., & Zimmerman, H. (2016). Women planning to major in computer science: Who are they and what makes them unique? *Computer Science Education, 26*, 277–298. https://doi.org/10.1080/08993408.2016.1271536.

Lim, K. M. (2016). Major matters: Exploration of the gender wage gap among STEM graduates (PhD dissertation, University of California). Retrieved from http://escholarship.org/uc/item/5d87v86c.

Margolis, J., & Fisher, A. (2002). *Unlocking the clubhouse: Women in computing.* Cambridge, MA: MIT Press.

Margolis, J., Fisher, A., & Miller, F. (2000). The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly, 28*, 104–127.

Margolis, J., Goode, J., & Chapman, G. (2015). An equity lens for scaling: A critical juncture for exploring computer science. *ACM Inroads, 6*(3), 58–66. https://doi.org/10.1145/2794294.

Marx, K., & Engels, F. (1970). *The German Ideology.* Lawrence & Wisehart.

Mellström, U. (2009). The intersection of gender, race and cultural boundaries, or why is computer science in Malaysia dominated by women? *Social Studies of Science, 39*, 885–907. https://doi.org/10.1177/0306312709334636.

Murphy, S. (2019). Participation and achievement in technology education: The impact of school location and socioeconomic status on senior secondary technology studies. *International Journal of Technology and Design Education.*. https://doi.org/10.1007/s10798-019-09499-4. Online publication.

Office of the Chief Scientist. (2016). *Women in STEM: A story of attrition (datasheet 2)*. Canberra, ACT: Australian Government. Retrieved from http://www.chiefscientist.gov.au/wp-content/uploads/OCS_Women_in_STEM_datasheet.pdf.

Rowan, L., & Lynch, J. (2011). The continued underrepresentation of girls in post-compulsory information technology courses: A direct challenge to teacher education. *Asia-Pacific Journal of Teacher Education, 39*, 83–95.

Sax, L. J., Lehman, K. J., Jacobs, J. A., Kanny, M. A., Lim, G., Monje-Paulson, L., & Zimmerman, H. B. (2017). Anatomy of an enduring gender gap: The evolution of women's participation in computer science. *The Journal of Higher Education, 88*, 258–293. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/00221546.2016.1257306.

Singh, K., Allen, K. R., Scheckler, R., & Darlington, L. (2007). Women in computer-related majors: A critical synthesis of research and theory from 1994 to 2005. *Review of Educational Research, 77*(4), 500–533. Retrieved from https://journals.sagepub.com/doi/abs/10.3102/0034654307309919.

Smith, D. E. (2005). *Institutional Ethnography: A Sociology for the People*. AltaMira.

Spieler, B., Grandl, M., Ebner, M., & Slany, W. (2019). "Computer science for all": Concepts to engage teenagers and non-CS students in technology. In L. Elbk (Ed.), *Proceedings of the 13th European Conference on Games Based Learning (pp. 667–674)* (Odense).

Stetsenko, A. (2017). *The transformative mind. Expanding Vygotsky's approach to development and education*. New York, NY: Cambridge University Press.

Stoilescu, D., & McDougall, D. (2011). Gender digital divide and challenges in undergraduate computer science programs. *Canadian Journal of Education, 34*, 308–333. Retrieved from http://journals.sfu.ca/cje/index.php/cje-rce/article/view/461.

Thébaud, S., & Charles, M. (2018). Segregation, stereotypes. *and STEM. Social Sciences, 7*(7). https://doi.org/10.3390/socsci7070111.

Vadeboncoeur, J. (2017). *Vygotsky and the promise of public education*. New York, NY: Peter Lang.

Vadeboncoeur, J. (2019). Mapping imagination through transitions within, between and from imaginative play: Changing demands as developmental opportunities. In M. Hedegaard, & M. Fleer (Eds.), *Children's transitions in everyday life and institutions* (pp. 227–246). London, England: Bloomsbury.

Vadeboncoeur, J., & Padilla-Petry, P. (2017). Learning from teaching in alternative and flexible education settings. *Teaching Education, 28*(1), 1–7. Retrieved from https://www.tandfonline.com/doi/full/10.1080/10476210.2016.1265928.

Vadeboncoeur, J. A., Kady-Rachid, H., & Moghtader, B. (2014). *Learning in and across contexts: Reimagining education*. New York, NY: Teachers College, Columbia University.

Vadeboncoeur, J. A., Perone, A., & Panina-Beard, N. (2016). Creativity as a practice of free- dom: Imaginative play, moral imagination, and the production of culture. In V. P. Glaveanu (Ed.), *The handbook of creativity and culture research* (pp. 285–305). United Kingdom: Palgrave Macmillan.

Vadeboncoeur, J. A., & Vellos, R. E. (2016). Re-creating social futures: The role of the moral imagination in student–teacher relationships in alternative education. International Journal of Child, Youth and Family. *Studies, 7*, 307–323. https://doi.org/10.18357/ijcyfs72201615723.

Vekiri, I. (2013). Information science instruction and changes in girls' and boy's expectancy and value beliefs: In search of gender-equitable pedagogical practices. *Computers & Education, 64*, 104–115. https://doi.org/10.1016/j.compedu.2013.01.011.

Vygotsky, L. S. (1987). *The collected works of L. S. Vygotsky: Problems of general psychology—Thinking and speech (N. Minick, Trans., Vol. 1). New York, NY: Plenum Press*.

Vygotsky, L. S. (1997). *Educational psychology*. Boca Raton, FL: St Lucie Press.

Vygotsky, L. S. (2004). Imagination and creativity in childhood. *Journal of Russian & East European Psychology, 42*(1), 7–97. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/10610405.2004.11059210.

Wiersma, W., & Jurs, S. (2009). *Research methods in education: An introduction*. Boston, MA: Pearson International.