

Understanding Women's Presence in ICT: the Life Course Perspective

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ABSTRACT

Considerable effort has been devoted to reaching a gender balance in ICT professions, apparently to little effect. Women still make up under 20% of ICT professionals in most OECD countries, and there is little sign of any substantial increase in their presence. Perhaps we have failed to properly understand the factors involved in women's absence, or to design appropriate remedial measures. We may need to reconsider our approach to the issue.

In this paper, we advocate a 'life course' approach to the understanding of women's trajectories through ICT studies and careers, situated in the structural and cultural contexts within which these trajectories unfold. This approach has several advantages: it allows us to identify the main factors affecting women's engagement in ICT at different points in their lives; it highlights the key transition and attrition points in women's lives; and, it shows how their career patterns are shaped by domestic labour as well as workplace factors. It crucially recognises the role of women's own choices, as they shape and respond to their situations. Several contextual issues also appear to be crucial in shaping patterns of women's engagement in ICT. In different countries, there are contrasting education systems, gender regimes and family structures, and employment cultures. All have a decisive influence on women's careers in the ICT professions in every country. Using this approach, we can identify life events and contextual issues which require targeted action, and thus differentiate practical priorities according to different circumstances.

KEYWORDS

ICT; women; gender; life course.

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INTRODUCTION

The low and declining proportion of women in computing has been widely noticed and much lamented (Cohoon and Aspray, 2006; OECD 2007; Kirkup et al., 2010; Misa, 2010). The entry of women into ICT education and employment has not only stalled, but has gone into reverse, in the sense that their representation in certain areas of computing education and computing work has begun to decrease in some countries.

The participation of women in ICT-related studies and employment exhibits the following patterns:

- In most OECD countries, the share of women in computing-related degree courses ranges from just under 10% to a maximum of 30%.
- Employment in the ICT sector is dominated by men, the share of women ranging between 15% and 40% in the OECD countries in 2007.
- Women make up less than 25% of ICT specialists in the US, 20% in northern European countries, and 10-15% of them elsewhere in the OECD. These rates are stagnant or declining in most countries.
- Within the category of 'ICT specialists', the presence of women varies. They are 7% of highly skilled specialists (computer and electronic engineers) but 50% of less skilled ones (analysts, operators, data base administrators) (all data from OECD, 2007). On the other hand, the rate of feminisation of ICT user occupations is between 60% and 95%, and is increasing¹.

In the European Union, the gender gap in ICT professions has widened over time. In the five years 2001–2006, the proportion of men working in computing jobs in the EU increased by 0.3 % (from 2.3% to 2.6%), whereas the proportion of women remained at 0.7% (Eurostat, 2007).

The reasons for this stagnation are less well understood. In this sense, perhaps our frameworks for addressing the under-representation of women in computing have failed us. Both conceptually, in terms of our understanding of the complex reasons for women's under-representation, and practically, in terms of our tools for action, we appear to have moved forward very little, if at all.

We believe that there is a pressing need for an analytical framework which better supports our understanding of why and how women have come to be so absent from almost all types of computing activity – education, employment, design, management, leadership. We know from the accumulated research in this field that the factors involved in their under-representation in these areas are varied and complex, ranging from the teaching and the curriculum of computing; the performance of gender in ICT activities; girls' and women's orientation to computing; the masculine culture and organisation of ICT work and working time; the valuation and accreditation of different types of computing skills; and the combination of age and gender discrimination. Several studies have identified

these and other factors in women's under-representation (for example, Wajcman, 1991; Margolis and Fisher, 2002 ; Woodfield, 2002; Platman and Taylor, 2004; Castaño, 2005; Webster, 2005; Simard et al., 2008; Eccles et al., 1999). But are these factors interconnected, and if so, how? Does women's absence in one sphere have implications for their participation in another? And, by implication, if interventions to improve women's situation were made in one area of under-representation, would they have benefits in other areas? We do not really have a clear framework for connecting these different issues and for understanding how, if it all, they interact with one another.

We also need an improved explanatory framework in order to properly analyse the state of affairs in different cultural settings – particularly in different countries. Although most of the research insights gathered to date have concerned the Anglo-Saxon countries (particularly the USA and the UK), empirically, there is a developing picture of women's situation in other countries: in non-Anglophone western Europe (for example, Lie 2003; Valenduc et al., 2005; Castaño et al., 2010; Typas et al., 2010); in southern and eastern Europe (Turner, 2005), in Africa (Rathgeber and Adera, 2000); and in south east Asia and India (Ng, 2005; D'Mello, 2006). These studies provide a nuanced picture, and suggest that some of the explanation for variation lies in the different social contexts and social arrangements within which ICT education and employment takes place: the educational culture and curriculum structure; the gender culture of the society; women's labour market situation; and the provision of support systems by the state, the family, and other institutions. Our conceptual tools for understanding these variations need to be articulated and advanced.

In the course of conducting a comparative analysis of the situation of women in ICT in one southern and one northern European country (Spain and the UK), and of consequent public policy interventions in the two countries, we are seeking to develop a conceptual framework which aims to link in a coherent way the insights of existing literature on the factors involved in women's under-representation in the field, while at the same time making provision for the differing social contexts shaping women's ICT careers (Palmén, Webster and Castaño, 2010).² For us, the existing dominant discourse based on the analogy of the 'leaky pipeline' – the idea of a progressively reduced 'flow' of women through ICT education and employment – as the explanation for their attrition from computing has serious limitations, most serious among which are its inability to locate women's ICT trajectories (through their educational and working lives) in their wider social context, and its failure to discuss women's agency in their own ICT career formation. In this paper, we set out our proposals for a renewed conceptual framework which aims to address and correct these and other limitations.

Our ideas were strongly influenced by the work of Xie and Shauman (2004) who advocate a 'life course' perspective for understanding women's pathways through science. We have drawn heavily on their work in our analysis of women's trajectories in ICT, and we owe them a substantial intellectual debt. Although their work acknowledges the importance of a contextual understanding of how women's careers are shaped, their perspective does not, however, explore the different

institutional, social, cultural and other dimensions of that context extensively. This may be because their analysis focuses primarily on the United States, so they have not needed to make provision within it for alternative social structures (although, of course, these vary greatly between individual states as well as between the U.S. and elsewhere). Our framework is designed to go further: because our analysis is fundamentally cross-cultural in focus, our framework facilitates inter-societal comparison between educational systems, gender arrangements, family structures, welfare models and employment cultures. The differences between these arrangements in Spain and the UK alone are substantial, and it is important that their significance for women in ICT can be captured. If, as we would like, we were to add other countries and cultures to our analysis, the argument for such an approach would be strengthened.

The framework we present here also offers a conceptual tool for reading the empirical material that follows in the other papers in this volume. Our aim in developing the framework has been to support assessment of the relative importance of, and interactions between, the different factors at work in influencing women's pathways through ICT. In other words, our purpose has been to construct a framework which can promote a better understanding of how, throughout their life courses, women's experiences in ICT education and employment intersect, build, contradict, but also reflect the wider social arrangements in which they unfold.

MOVING BEYOND THE 'LEAKY PIPELINE' APPROACH

The metaphor of the 'Leaky Pipeline' was first deployed to represent the attrition of women from science (Berryman, 1983). It refers to the phenomenon in which women progressively disappear from scientific careers, so that a focus on progressive points along the pipeline will reveal fewer and fewer women. Effectively, the pipeline is a metaphor for their leaking out of science careers: as the pipeline progresses, it narrows, and more women 'leak away'. This calls attention to the structural leakage points in the pipeline, the joints, at which women disappear. It also implies that policy and practical measures to improve women's presence and progress in science careers must be geared to stopping the leaks.

The leaky pipeline analogy has similarly been deployed to understand the pattern of women's disappearance from ICT professions (for example, Camp, 1997; Gras-Velazquez et al., 2009). The contention is that girls and women progressively drift away from ICT studies and career choices through the education process and after. ICT employers complain that the available female talent pool from which they can recruit is small. Even those who do enter ICT professions do not enjoy the same positions, pay and conditions as their male counterparts, and have far-from-smooth career trajectories over their lifetimes. The labour supply pipeline continues to leak throughout employment, and as the ICT career progresses, women's presence in the sector progressively diminishes, such that they are almost entirely absent from senior roles in ICT professions and sectors.

Although the leaky pipeline approach has been widely used and is extremely influential in explaining women's absence from science careers, it has recently

become the subject of sustained critique for its failure to adequately address the complex reasons why women are under-represented in science (Evetts, 1996; Xie and Shauman, 2003; Leventman, 2007; Addis, 2010; Bennett et al., 2010). In our view, many of the same points of critique apply to the use of this framework to explain women's absence from ICT careers, and they are summarised in the following discussion.

The Leaky Pipeline Implies a Linear Progression through an ICT Career

The first difficulty with the leaky pipeline framework is its linearity. It implies an orderly progression through the stages of education, labour market entry and career development, with an ideal-typical timescale for this progression, and it also implies that the successful completion of all stages involves a positive outcome. Consequently, it makes no provision for alternative educational or career pathways. For example, in the linear pathway through science or ICT, education necessarily precedes employment; this framework does not recognise that education – or at least learning – might also occur within employment, or indeed afterwards. Separating education from employment into distinct and linear phases of life, as the leaky pipeline approach does, is a particular problem for a metaphor designed to address this type of work. In the knowledge economy generally, and in ICT employment specifically, education and learning are undertaken throughout the career, even throughout life (Bartol and Asprey, 2006: 379). Empirically, too, there is growing evidence undermining the idea of a linear progression, since many ICT jobs are filled by people from other disciplines, or by those who enter the ICT labour market after having worked in other professional fields (Bartol and Asprey, 2006; Valenduc, 2011). Indeed, this is particularly true of women's entry to ICT employment (Leventman, 2007). So there are many different paths to an IT career, and it is not true of even the majority of IT workers, male or female, that they enter IT jobs through this pipeline as it is typically conceived (Bartol and Asprey, 2006: 380).

A related drawback of this approach is that, in reality, employees do not always progress 'forwards' in their careers as the linear emphasis implies. Women often move 'backwards', particularly, for example, when accepting jobs below their qualification or experience level after maternity, or upon family mobility (Bennett et al., 2010).

Finally, an emphasis on a linear series of transitions from school to college to work is gender-blind: it does not acknowledge the careers of those, including women, who have non-traditional (for men) educational and employment trajectories, and who move in and out of education and the labour market in response to their changing domestic circumstances and family relationships. As Xie and Shauman argue, the leaky pipeline framework

... equates non-compliance with the normative career trajectory to "leaking" or "dropping out" of the pipeline. This characterization is reified by research that narrowly focuses on gender differences in exits from science/engineering ... at the expense of not studying the

actual, often complicated pathways followed by men and women in the pursuit of science careers (Xie and Shauman, 2003: 8).

The Leaky Pipeline Conceives the Problem of Women's Under-Representation in a Social, Institutional and Cultural Vacuum

The leaky pipeline model does not locate the scientific or technical career within broader context of people's lived experiences. Progression along the pipeline is presumed to be independent of personal or social situation, including other life course events which we know intersect with career formation and development (Xie and Shauman, 2003). Yet women's engagement with the labour market generally, and with science and technology careers specifically, is often sporadic, and cannot be understood without reference to other life events, such as family formation, geographical mobility, and elderly care activities, all shaped by women's role in the domestic sphere. Clearly, the organisation of family and household labour influence the ability of women to pursue their employment and careers, and these gender divisions of labour vary across societies. Women's engagement with ICT careers has to be assessed within these contexts. Once these issues are taken into account, the feasibility of a framework which emphasises linear career progression becomes still more questionable.

The Leaky Pipeline Framework Obscures Women's Agency in their Careers

The pipeline concept implies a (female) labour supply entering the pipe, and leaking out in the process of travel along the education and employment trajectory. Those women who remain in the pipeline are seen as resources upon which universities, and later employers, can draw. The analogy focuses mainly on the characteristics and leakage points of the pipeline, but the women – the labour supply – is undifferentiated and apparently without agency. As a result, the framework does not really consider the women's own decisions or choices about their pathways. Yet as we have already commented, women's choices are shaped by their perceptions of the options open to them, which are in turn dictated by a plethora of factors including: the cost, quality and availability of child- and elderly care; the impact of government policies; their family backgrounds; the flexible working options available to them and their prior employment histories (Bennett et al., 2010). For us, these factors are the products of gender and other socio-cultural arrangements of different societies (Pfau-Effinger, 1998, 2010; Esping-Andersen, 1990), and we discuss their role in more detail later in this paper.

The Leaky Pipeline is Functionalist as Well as Normative

Also implicit in the leaky pipeline model is the notion that, provided the woman scientist or technologist survives the many points of attrition, there will be no inherent obstacles to her progressive advancement through the educational and employment systems on the basis of her merit. In this conception, aside from the structural problems of the pipeline's leakage points, there is no consideration of problematic social relations or social processes *within* the pipeline – in the education or employment arenas. Yet a characteristic of many social spheres where women have entered, particularly those which have in the past been male-dominated, is the active organisational undermining of women or the undervaluing of women's contribution (see, for example, Margolis and Fisher, 2002, in relation to

ICT education; Woodfield, 2000 in relation to ICT employment). For example, the achievements of female professionals are frequently attributed to their male colleagues or otherwise minimised or underestimated, a phenomenon known in science studies as the 'Matilda effect' because of its gender relevance (Addis and Brouns, 2004). The subtle practices taking place within educational institutions or employing organisations can stall women's progression through their careers, and may even reverse their progression. The leaky pipeline analogy is, in our view, poorly equipped to cater for such dynamics, because it assumes that provided the woman scientist or technologist remains *within* the field and does not leave it, she will progress through it.

Because of the drawbacks of the leaky pipeline framework discussed above, it has been suggested that it restricts the kinds of questions that can be asked by researchers (Xie and Shauman, 2003), thereby restricting the coverage of empirical research. For us this is a very serious limitation, for we are concerned here with two aspects of women's ICT careers which the framework cannot support. First, we want to provide a framework which can support an assessment of the widest possible body of empirical evidence concerning women's participation in ICT education and careers. This requires a much more comprehensive framework than the leaky pipeline provides, and one that is non-normative. Second, our project is as much a practical as an empirical one: we are seeking here to formulate a framework that can help us understand the design and orientation of practical measures to promote and support women in ICT in different country contexts. Specifically, our aim is to locate these measures within particular policy frames and as responses to particular policy problems (Verloo and Pantelidou Maloutas, 2005) that arise in different settings, in order to assess what their aims, coverage, and outcomes have been. We offer below a conceptualisation of women's ICT careers which aims to be both more empirically comprehensive and more practically responsive than the leaky pipeline is.

THE LIFE COURSE APPROACH

Originating in demographic studies and social history (Elder, 1999; O'Rand and Kreckler, 1990; Hutchinson, 2008), the life course approach was adopted as a conceptual framework by Xie and Shauman (2003) for analysing women's careers in science. The concept of the life course turns on the idea of a sequence of stages in individuals' lives, following different pathways. Several key concepts are used to describe and analyse differences in life courses: 'transitions' are changes in roles and statuses experienced by individual women or men; 'trajectories' are long-term patterns of stability and change that involve multiple transitions in an individual's life; 'life events' are significant occurrences involving relatively abrupt change that may produce serious long lasting events in an individual's life; and 'turning points' are a substantial change or discontinuity in direction that is not temporary, but lasting (Elder, 1999; Hutchinson, 2008).

In advocating a 'life course approach' to the understanding of women's careers in ICT, our central contention is that life events (family relationships, educational choices and achievements, family formation, geographical mobility patterns, labour market participation patterns and decisions) separately and in combination

influence women's ability to engage in this field, in ways which differ substantially from men's and which then have a decisive impact on their careers. In the central section of this paper, we draw on the insights of existing research into women's ICT trajectories through education, employment entry, and early career formation, using the concepts of the life course to understand them. Not all women experience the same life events, of course, and we are not seeking to represent all women's life courses as linear transitions through education, employment and motherhood. Rather, this is a model of the issues affecting women collectively and the ways in which these issues affect their ICT trajectories.

Equally, people's lives do not unfold in a vacuum; they are shaped by the social, economic, cultural and political environments within which people live, and these vary across different societies. As we have commented, we cannot fully understand how women navigate through their education and working lives without considering issues such as the social support arrangements for working women, including the provision of child- and elderly care, flexible working options, gender cultures, and the general framing of gender equality policies in different societies. In the countries which have been the focus of our work to date, Spain and the UK, there are substantial contextual differences – for example, in gender orders (Connell, 1995), in the labour market, and in welfare regimes (Esping-Andersen, 1990). In Spain, women's entry to the labour market, after many decades of consignment to the home during the Franco era, has been recent, compared to the UK and elsewhere in the advanced capitalist world. The labour market, too, is extremely rigid and most women have little option but to work full-time, unlike in the UK, where flexible working arrangements are diverse and extensive. Caring (for children or for the elderly) is done predominantly by women, who draw upon the extended family and migrant workers. In the UK, care work is shared somewhat more equally between the sexes, and a large part is delivered through the market.

We propose, therefore, a framework which includes recognition of the factors which create the environments and circumstances of women's and men's lives. These fall into a number of broad categories:

- Educational contexts: these include the structuring and staffing of education in general and computing education in particular.
- Household and family structures: these include breadwinner/carer models (such as the 'male breadwinner/female carer' model or the 'dual breadwinner/dual carer' model), and the ways in which these are related to the welfare systems in different societies (Pfau-Effinger, 1998; Esping-Andersen, 2009) which influence the provision of care for dependents, culturally dominant domestic divisions of labour, and cultural attitudes to working women.
- Labour market structures, policies and legislation: these affect working time arrangements and cultures, such as the provision and take-up of flexible working arrangements, and the cultural acceptability of long working hours.
- Equality cultures and legislation: these cultures and legislative frameworks shape social attitudes to women's employment. They include maternity and parental leave provision, return to work provision, gender quotas and other

legislation for equal rights, and create the conditions for women's labour market engagement and progression (Duncan, 2001; Olgiati and Shapiro, 2002).

- Organisational structures and cultures: these create the conditions for specific recruitment, training, progression and attrition policies and practices. They vary according to the ownership, global reach and management of the organisation and on whether it is a public or a private sector employer.

We also want to emphasise the intersection between the environments within which women's working lives are lived and their own actions in shaping their career trajectories: the connections between the structural, the cultural and the personal. So, for example, the Spanish gender order has influenced both Spanish women's labour market participation patterns and cultural attitudes to women's work. These patterns and attitudes also contrast markedly with those in the UK, where women's paid employment is much longer-established, more culturally accepted, and supported by policies which increasingly emphasise flexible labour market engagement and work organisation. At the level of employing organisations in the different countries, work cultures and working arrangements vary from public to private sectors and between global multi-national corporations and local firms. These cultures and forms of work organisations influence working time arrangements, affect the valuing of skills along gender lines, and shape the gender culture of organisational life (Gherardi, 1995). These create the varied environments within which women's ICT studies and careers develop.

But women also respond to and shape these environments, taking decisions about career choices that respond to their gender identity and sense of personal purpose, to their educational experience, to their domestic situation and the practical challenges of managing their lives, and to their willingness to engage in sometimes hostile gender cultures at work. Just as much as their ICT career paths are externally influenced, they also negotiate their trajectories through them. The work of Griffiths et al. (2006) has been particularly important in emphasising the nuances of women's experiences and responses in relation to their careers in ICT and their caring responsibilities; their work focuses on the intersection between the life stages and the career stages of female ICT professionals in the UK, and offers an important corrective to the idea that women's experiences and trajectories in ICT are homogenous.

Our approach also seeks to illuminate the complexity of women's trajectories through ICT studies and careers. It includes attention to the interaction between social structures, social processes, and individual processes, showing how the trajectories of groups of women and those of individual women are affected by similar social contexts, and are characterised by the same types of transitions, even though they are modified by individual life events.

If we look at women's and men's life courses, we can see the factors operating to affect their presence in ICT: the engagement and disengagement of girls and women from ICT; situations that can create advantages for boys and men and disadvantages for girls and women. We can focus on the key turning points that bring about a change of trajectory and on women's personal decisions about their

lives. The following discussion draws on examples from the substantial body of existing international empirical research in this area, including research from Spain and the UK, which we deploy to show how the conditions of ICT education and employment influence and intersect with life course events to shape women's pathways through this professional area: the obstacles they create, the responses women make and the resulting journeys they take.

Education

In adolescence, girls' and boys' experiences of technology are complex, shaped by individual orientation, family dynamics, and group processes in the school system (Margolis and Fisher, 2002; Cohoon, 2011; Sáinz, 2007). At the individual level, gender identity formation and personal orientations to computing are key processes (Sáinz, 2011). In the family, gender stereotypes are constructed and enacted, and perceptions of ICT careers assume a gender label. All of these processes are governed partly by the gender orders in different societies. Gender identity formation and gender stereotyping in a southern European country with a strong tradition of Catholicism, such as Spain, is likely to operate rather differently than it will in a country with a predominantly secular culture and a more established history of gender equality, such as the UK.

At school, the sex of ICT teachers, their competence in the subject, and the coverage of the curriculum all play a role in encouraging or discouraging girls' and boys' from engaging with ICT (AAUW, 2000; Goode, Estrella and Margolis, 2006; Palmen, 2011). Children perform gender around computers at school: research shows that boys are invariably self-confident with computers, while girls typically have a much lower perception of their own computing abilities (Eccles, 1994; Sáinz et al., 2009; Sáinz, 2011; Palmen, 2011; Gras-Velazquez et al., 2009). They make their study choices on the basis of their stereotypes and their self-perceptions.

At the transition point from school to further learning and a career, there is considerable peer pressure on girls to conform to traditionally female learning and career choices (Sáinz, 2007, 2011). This peer pressure is exacerbated by the scarcity of good careers advice in many countries, including Spain and the UK. Additionally, in the UK, vocational training is extremely sex-segregated: in ICT-engineering is strongly male-dominated, while traditionally female training subjects remain very female-dominated (Kirkup, 2011). Research from southern European and Anglo-Saxon countries alike has found that many girls express a preference for studying subjects which will lead to socially useful work (Eccles, Barber and Jozefowicz, 1999; Margolis and Fisher, 2003; Sáinz et al., 2009). All of these accumulated issues affect the study and career choices of girls, so that they tend to choose subjects other than technology and engineering, which are often the first choices of boys. Their trajectories move away from ICT studies.

Following their schooling, young women disengage noticeably from ICT as a potential specialism or career. Computing degree courses discourage women's entry (in the requirement for previous programming experience, in the gender imbalance of ICT students (Salminen-Karlsson, 2011; Müller, 2011) in the image of

computing studies, and in the social stereotypes of ICT workers as 'freakies' (Cohoon and Aspray, 2006).

Those women who do embark on a trajectory of ICT studies encounter a series of obstacles to its progress and a hostile learning environment, in particular, a highly masculine culture and pedagogy in computing degree programmes, with a strong emphasis on abstract mathematical knowledge and little on the social applications of computing. This culture, together with a scarcity of female role models and mentors, infrequency of staff-student interaction and absence of peer support (Müller et al., 2011), affects the morale and motivation of female students, many of whom drop out during or after their degrees (Margolis and Fisher, 2002).

Employment

A further transition comes with entry to employment. Several inhibitors to women's entry and participation in ICT work have been identified. Recruitment and progression processes tend to place considerable value on technical skills in programming and network design. A particular feature of ICT work is that technical knowledge quickly becomes outdated, so that constant refreshment is needed to keep it current (Guzman et al., 2009; Glover and Evans, 2011). This can be done more readily by those in the labour market than by those on career breaks and even temporarily unfamiliar with the state of play in employing organisations. So the first transition to ICT employment is difficult for those without 'traditional' technical skills.

Promotion also seems to depend on the primacy of these sorts of skills, even if appearances suggest otherwise. The emergence of hybrid skills in the shift towards service provision in ICT companies might be supposed to be favourable to women who are assumed to be good communicators (Glover and Guerrier, 2010), but studies from the UK show that hybrid skills are not treated as 'real' skills, unless they are associated with technical skills and positions which reflect traditional gender hierarchies (Woodfield, 2000, 2002; Glover and Guerrier, 2010). In employee appraisals, these skills are often overlooked. This seems consistent with the conclusion that, in general, skills associated with femininity are frequently undervalued (Philips and Taylor, 1980).

Throughout women's careers in ICT, the individualisation of employment relations, including the negotiation of contracts, pay and working conditions that is widespread in ICT employment (and a particularly common practice in multinational companies), has serious implications for women's pay and careers. It removes transparency from the bargaining process, and obscures the criteria by which promotions are made (Valenduc et al., 2005; Webster, 2004). Pay inequality is rife in the sector, certainly in Spain and the UK, and probably elsewhere (Tattersall et al., 2007; Iglesias, Llorente and Dueñas, 2010; Valenduc, 2011). Moreover, the long, unpredictable and unsocial hours, and requirement for remote working on client premises, are demanding and difficult to manage, particularly in conjunction with domestic responsibilities. These are aspects of ICT employment which, taken in combination, create specific obstacles for women seeking to enter and advance in this sphere of work.

Women who become mothers and later return to work seem to have two broad sets of responses to these strictures. At and after family formation, some women can appear less committed to their work, and on top of this they begin to experience discrimination in promotion opportunities. At this life stage, they reach another turning point, and many women respond by dropping out of their ICT careers altogether (Griffiths and Moore, 2010). Others respond differently, showing substantial enthusiasm for, and commitment to, their technical work, and reject the idea that 'real womanhood' is antithetical to it (Henwood, 1993; Faulkner, 2009). But even those women who do not become mothers and have a strong commitment to their work report that they experience a dilemma between this commitment and their private lives, including their family responsibilities (Teague, 2002; Bartol et al., 2006; Vázquez, 2010). The social support that they can access during these transitions and life events (such as the provision of child- and other care, whether through the family, the private sector or the state) has an enormous impact on their ability to engage in ICT careers. In Spain, as we have already pointed out, care is largely delivered through the extended family and through the army of 'chicas', immigrant women who take care of a range of domestic duties and on whom the Spanish economy depends. In the UK, care is privatised and marketised, so that its availability and affordability are key determinants of the terms on which women with caring responsibilities can continue to engage in the labour market. In the light of these organisational and cultural processes in ICT, how do women in ICT work make choices about their personal and professional situations?

The multiple barriers to young women's career development lead many women to leave ICT work early in their careers (EOC, 2004; Griffiths and Moore, 2010). These barriers recur and are exacerbated for women during maternity and immediately after. Women who have had children undergo a different transition, in that they now live between two worlds - the world of work and the world of the family. This is a period of particular tension, for the years of maternity and family formation coincide with the decisive years in career development (Rubsamen-Waigmann et al., 2003; Simard et al., 2008; Caprile and Vallés, 2010; Vázquez, 2010).

Return to ICT employment for mothers following their maternity is therefore an equally difficult transition. Many women returners to ICT lament the loss of their personal networks and their self-confidence (Herman and Webster, 2010), as women returners more generally do. In ICT work, though, there is the specific difficulty of managing the long working hours and the need for constant skills updating, whilst simultaneously engaging on the project of reconstructing professional networks and credibility. Some women choose to postpone maternity while they are developing their careers. Others bypass maternity altogether (Griffiths et al., 2006). But there is evidence that they still face stereotyped assumptions about the likelihood of family responsibilities undermining their career commitment, assumptions that affect their opportunities for progression, even if they do not have partners or children at all (Kanter, 1977; Wajcman, 1998).

There is a small, but growing, body of research evidence concerning the nature of women's ICT trajectories at mid-career, which is considered to be another significant turning point (Dalton et al., 1977; Simard et al., 2008; Palmén et al., 2010). Ageing brings with it a set of challenges in addition to those connected to gender (Platman and Taylor, 2004; Griffiths et al., 2006). Organisational obstacles to progression into senior roles combine with personal life events. At work, poor line management and age-plus-sex discrimination affects mid-career women's opportunities. Life course events such as growing responsibility for care of elderly relatives in combination with continuing responsibility for children create difficulties for women in senior roles. In the absence of shared caring in the home, and dependable, affordable care provided within the wider society, many women in mid-career choose to leave their organisations completely and move into an area of work that is more personally and professionally sustainable.

TAKING THE ANALYSIS FORWARD

Although in the foregoing discussion we have emphasised aspects of commonality in women's ICT career trajectories, within and across cultures, we do not regard these as either uniform or linear. The approach that we are advocating in this paper centres on the interactions between structural, organisational and individual processes which differentially shape women's journeys through their ICT careers, even though the types of life events, transitions and turning points that they experience are broadly similar. As we have commented, the pathways of individual women are also the result of their own responses, decisions and choices, and in this paper we have drawn out some of the personal choices that research in this area has revealed.

For us, then, the conceptual focus on the life course is a useful way of understanding women's trajectories through ICT education and employment. We have also found it to be a helpful framework for addressing cross-national data, elucidating cultural differences and assessing their implications for the gender relations of ICT. To summarise our reasons for adopting this approach, we conclude by reviewing its advantages and reflecting on how it can help to advance both intellectual analysis and practical action. There are four main issues we wish to highlight again here.

First, we believe that this approach is context-sensitive. Where the leaky pipeline focuses purely on the workings of the pipeline itself as a way of understanding women's science or ICT careers, the life course perspective is multi-dimensional and context-aware. In our analytical framework, we have emphasised the interactive effects of social, economic, political, institutional, cultural and individual influences on women's ICT life courses – the ways in which societal processes and individual actions combine to play a role in the shaping of women's ICT careers. So, for example, we see computing education as formed partly by wider educational priorities and dominant knowledge systems (the emphasis in some educational systems on the mathematics and engineering constituents of computing knowledge). The curriculum and culture of computing education excludes and discourages many girls from pursuing this field of study, classroom processes and teacher behaviour may discriminate against them, and girls also make decisions

about their subject choices based on their own interest in computing and perceptions of their abilities.

This framework, then, offers advantages over the 'leaky pipeline' approach, which, by contrast, does not address the multiple contexts within which ICT careers are formed and developed. This attention to context is particularly important for our analysis, which aims to understand, first, the role of different country-level factors, such as gender regimes and educational systems; second, the role of organisational processes in the ICT sector which are specific to this area of work, such as the individualisation of employment, the emphasis on self-development and the frequent need for remote working; and, third, the role of individual women's choices, in influencing their pathways through ICT studies and jobs. Thus far, we are using the framework to analyse data across two contrasting European countries. A good test of its robustness would be to apply it using data from a wider range of settings, not only from Europe, but crucially from beyond, perhaps most usefully from the emerging economies where a considerable level of ICT economic activity is now taking place.

Second, the life course approach is gender-sensitive. It highlights the complex intersections between the trajectories people experience not only in education and employment, but also in their family and private lives. It acknowledges what feminist research has long insisted upon: that women's and men's career experiences can only be understood in this context. Although they do not explicitly refer to the advantages of this approach for a gender analysis, Xie and Shauman draw attention to the life events which include family formation, family mobility and family responsibility. Implicit in their formulation is an acknowledgement of the importance of the domestic division of labour for women's and men's labour market experiences and of the fact that, in most countries, adult women remain primarily responsible for child care and elderly care. Again, this is important for cross-national analysis of women's careers in ICT, for it supports a recognition of cultural variations in household, domestic and family arrangements and their influence on paid work (Pfau-Effinger, 2010).

Third, because this approach focuses on life events, transitions and turning points, it caters not only for linear trajectories but also for non-linear complex trajectories. This too is vital in the analysis of women's careers, which rarely follow a linear pattern and which classically involve multiple moments of entry and exit from the labour market, influenced strongly by events outside of the labour market, particularly family events.

The life course approach can reveal the significance of chronological events even when illuminating a non-linear career. For example, it can show the cumulative nature of some life events, highlighting the linkages between early life experiences and later ones. Separate incidents or processes at particular moments can, in combination, have a major influence on people's overall opportunities, decisions and courses of action. Thus, we may discern 'cumulative disadvantage', or indeed 'cumulative discrimination', in some women's pathways through their ICT education and employment that is particularly pronounced because of the sector's working

conditions. The impact of one life event may be reinforced by that of other subsequent life events, so that they collectively facilitate or inhibit women's entry into, and progress within, these fields. So we can analyse the effects on social groups (in this case, women) of the structural, cultural, and institutional arrangements in their societies, and in computing education and employment. We can also use this approach to examine the ways in which individuals may accumulate life and career events, which over time can reinforce one another in creating multiple layers of disadvantage in their ICT careers.

Fourth, a major advantage of this framework is its acknowledgement of the decisions, choices and actions of individuals in the shaping of their careers. There are many accounts of women's ICT careers which reveal the decisions women have actively taken to steer a particular course. Some of these accounts have focussed on women's refusal to enter or remain in the field, based on its perceived unattractiveness or the difficulties of managing such a career within the context of their non-work lives (see, for example, Margolis and Fisher, 2003; Griffiths and Moore, 2010). Others, however, have drawn attention to the positive choices women have made which challenge traditional binary definitions of gender: many women enjoy technical work and define their gender identities through their facility with computers (Henwood, 1993), while others find the work engaging for other reasons, and opt for a career in the field (Kelan, 2008).

For us, the usefulness of this approach is its focus on the way in which structural and cultural contexts influence women's life chances, life events and their educational, labour market and domestic decisions about their future, including their positive or negative choices about whether to participate in ICT careers. It is the intersection of these different aspects of structural and personal influences on ICT careers that strikes us as important, for it restores a sense of women as agents and not simply as passive victims of a masculine occupational structures and cultures. We do not take this to be an argument for complete individualism, however. Our framework also, and equally importantly, recognises that women's agency is not unconstrained. The opportunities that women have are both unequal to those of men and to one another, and their decisions are circumscribed by the reality of their situation and by their perceptions of their personal competences in the field on the basis of social expectations of them. Nevertheless, these self-perceptions and consequent personal choices are important elements in the complex picture of intersecting factors shaping women's ICT careers.

These are, in our view, intellectually compelling arguments for adopting a life course perspective, and developing the framework further to include social context as a key element in the analytical approach. This is vital to a cross-cultural comparison of women's participation in ICT, to any exploration of differences and similarities in participation patterns, and to an exploration of the reasons for these. We are engaged in such a comparative analysis of two countries, in the north and south of Europe. The need to widen the analyses to include other countries in order to achieve a more extensive picture of women's ICT careers, makes the case for such an approach all the more pressing.

At a practical level, this type of approach may be more fruitful than previous frameworks. It turns on the concepts of trajectories, life events, transitions, and turning points. Consequently, it permits special empirical attention to be paid to these key moments and their significance in women's ICT careers. It facilitates, for example, examination of transitions between education and work, into motherhood, or when women return to the labour market after a break. In terms of women's lives in ICT, these transitions points are of course empirically significant. They are also of key policy relevance, for they are moments at which policy and practical interventions are often targeted with the aim of supporting women's participation in ICT. An understanding of the intersecting influences on these periods in people's lives could contribute very powerfully to an assessment of the nature and timing of these transitions and turning points and how they are decisive for women's ICT careers. It is to be hoped that, as a result, this framework can also support more nuanced design and evaluation of policy measures addressed to these issues.

ENDNOTES

¹ The OECD (2006) distinguishes between 'ICT Specialist occupations' mostly devoted to designing ICT Systems, and 'ICT User occupations' which involve the use of software tools specific to their activity, although ICT is not essential to their work.

² This three-year project examines the situation of women in ICT professions in Spain and the UK, and compares the two countries' respective public policy responses. The study countries have been chosen for their contrasting gender orders (Connell, 1995) and public policy responses to the under-representation of women in ICT. The project started in November 2009 and will be completed in October 2012. It is conducted with the financial support of the Instituto de la Mujer (Institute for Women) in Spain. Financial support permitting, we aim in due course to extend our analysis to other countries which have made concerted public policy efforts to address gender inequality in this field.

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