Why Don't Women Program? Exploring Links between Gender, Technology and Software[1]

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The main question to be discussed in this article is: Why do women not program? In other words, why, in an activity that appears similar to others where women have gained ground, one cannot find an analogous process of incorporation? We propose a scheme of five related factors in order to analyse the genealogy of women's exclusion from the world of software. First, we discuss the relation between gender and technologies in general, focusing on the initial stages of socialisation. Second, we fast forward a few years in the lives of boys and girls and we analyse their first interaction with digital technologies. Next, in relation to puberty or adolescence, we inquire into peer-group dynamics which are established by those who dedicate much of their time to computers. Fourth, we take into account the gender gap in college or bachelor degrees related to informatics. Lastly, we analyse the common representations of and beliefs about gender that employers hold in relation to informatics workers. These five parts of the explanation have different foundations. Some rely strongly on our qualitative fieldwork in Buenos Aires; others are based on texts or statistics which belong to other authors.

Introduction

SEGREGATION OF WOMEN in the labour market is not at all a novelty. It comprises not only the segregation in certain productive areas, but also income disparity and differential opportunities in accessing hierarchical positions, among other issues. In Argentina, since the 1990s, there has been a growing feminisation of labour in several economic sectors, and a gradual reversion of the trend described above. Specifically, within what some authors refer to as Informational Work—activities that use digital technology as the main means of production, and whose primary output is digital information flow—women have gained positions. Indeed, in much

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of the so-called knowledge intensive activities, women have overcome some of the obstacles imposed by the patriarchal order. However, in an activity which is characteristic of the sector, 'software production', no progress in women's participation can be accounted for. With this in mind, this article intends to answer the following question: why, in an activity that appears similar to others where women have gained ground, can an analogous progress not be found?

Regarding our methodology, this article is based on qualitative fieldwork[2] that involved twenty-four in-depth interviews with female and male software producers, in Buenos Aires city, during 2010[3] and the use of secondary sources.

This article is organised as follows. The first section presents the contradiction between what happens in the labour market in general and what happens particularly in informational work, as opposed to what happens in software productive processes. The second section tries to review the contributions of previous literature, without claiming to be exhaustive. From this point on, five concentric rings are sketched out, five chronologically stratified levels, which together form our hypothesis on how gender segregation is constructed in software productive processes. These five parts of the explanation have different foundations. Some rely strongly on our fieldwork; others are based on texts or statistics which belong to other authors. In any case, we would like to highlight the necessity of considering these five factors when analysing the genealogy of women's exclusion in the world of software. It should be noted that our hypothesis is anchored in a specific generation: at best it can provide elements to understand current trends, but it will become obsolete as younger generations, with different trajectories to those described here, enter the labour market. In the third section we discuss the relation between gender and technologies in general, focusing on the initial stages of socialisation. Then we fast forward a few years in the lives of boys and girls and we discuss their first interactions with digital technologies. The fifth section is concerned with puberty or adolescence, and inquiries into the peer-group dynamics which are established by those who dedicate much of their time to computers. The sixth section analyses the gender gap in college or undergraduate studies related to informatics. The seventh section looks at/analyses the gender representations that employers of informatics workers possess. Lastly, we present our conclusions.

Women in General Informational Work and Specifically in Software Production

Worldwide, female employment has grown over the last few decades and the gender gap in the economically active population has been considerably reduced (being 52.7 per cent presently for women and 77.9 per cent for men, OIT, 2010). However, female workers are strongly grouped in some activities, such as domestic employment, caring activities, teaching and other services. In contrast, they are poorly represented in agricultural and industrial activities. Now, what do we find when observing their participation in the typical sectors of the so-called 'knowledge society'? Or, more precisely, to what extent do they take part in informational work; that is, in the production of digital information flows? There is strong evidence

suggesting that within these activities female participation is increasing. According to Manuel Castells, there is a direct correspondence between services linked to the informationalisation of the economy and the expansion of female labour in advanced countries (Castells, 1997, p. 252).

Regarding Argentina, within the private sector Research and Development 56.7 per cent of the workers are women (OEDE, 2010, Chart 2.8). A similar pattern emerges within the public sector: women account for a 51.6 per cent of the scholarship holders and researchers of the whole national system of science, technology and innovation (Baringoltz and Gauna, 2014). If we look at other activities where informational goods are the main output, we find similar results. For example, in publicity 50 per cent of the labour force is female[4] (Castillo et al., 2008, p. 51), while in outsourced call centres this reaches 70 per cent (Del Bono, 2006, p. 15).

All these activities have something in common: they primarily consist of the creation and processing of digital information flows by means of digital technologies. Female participation in such activities should not be a surprise: it consists of tasks that do not require much physical strength. In addition, these tasks are bound up with the discourse of political correctness and claim to, at least partly, take on board some of the ideas of gender equality.

However, there is a type of labour which consists, just as those mentioned previously, of the production of informational goods through computers, but which, contrary to this, does not register any significant feminisation: namely, software production. Even when it is an incredibly contemporary activity (meaning it does not carry in itself the hindrances of an even more patriarchal past), software processes maintain a persistent gender inequality. This tendency manifests itself both at a worldwide level[5] and in different types of software productive processes (Ghosh et al., 2002; Gupta and Houtz, 2000; Habtu, 2003; Hapnes and Sorensen, 1995; Krieger et al., 2006; Miller and Jagger, 2001; NSF, 2004).

Given this, for the Argentinean case, in 2009, it was estimated that only 34.7 per cent of the labour force (in private formal employment) in the informatics sector are women (OEDE, 2010, Chart 2.8). But the situation of women is even worse than the data suggests because the above-mentioned statistics only account for large and multinational companies, which have a much larger female presence than micro companies and other productive activities. Partly, this is due to the fact that within larger software producing companies, women are employed in roles that are complementary to the main activity (human resources, administrative activities, etc.). This fact gives a more balanced picture about gender equality while measuring the employment proportions of the whole productive unit. For instance, a study carried out in 2008 calculated a feminisation rate of 36 per cent, but only 24 per cent corresponded to women who programmed and developed software (Castillo et al., 2008). Moreover, our interviewees, workers in this type of industry, when questioned about women who take on specifically informatics tasks, offer even more asymmetric results: ten to one in multinational and big local companies.

Moreover, our fieldwork suggested that female participation in smaller productive processes is even lower than in big local companies, multinationals and the state.

Even though we cannot derive from this the real rate of female participation, but the two points mentioned earlier (discarding peripheral employment and including the 'invisible' productive processes) makes the 34.7 per cent female participation quoted before look as an exaggerated estimate.

Thus, a contrast emerges between the large number of women working within the informational sector and the much lower number of women working specifically in the production of software.

Additionally, a similar contrast can be found in the field of research and education.

Indeed, as we have seen above, while women equal men in the total number of researchers and scholarship holders, this is not the case in the information technology (IT) sector. Baringoltz and Gauna (2014) have found that out of the total researchers and scholarship holders in the field of IT only 29 per cent are women. Accordingly, women accounted, in the last available record, for just 19 per cent of students and 25 per cent of degree holders in computer science careers in Argentina.

With this, the central question in this article is addressed: if software production is similar to other informational activities where the female employment rate is at least similar to that of men, *why is there such a modest proportion of women in software production*? Over the next section we will address a number of milestones in previous literature, and in the five remaining sections we offer a number of hypotheses.

Previous Literature: Gender and Technology

Literature about the relation between gender and technology started to flourish in the 1980s, entering into dialogue with the feminist perspectives that preceded it.[6] This results in the Feminist Technology Studies (FTS) field (Bray, 2012). Despite its youth, it is a field vast enough to have already provided some useful classifications. Here we combine the simple taxonomies exposed by Faulkner (2001) and Wajcman (2009) with one equally as simple, proposed by Feenberg (1991) for the philosophy of technology in general. Roughly, we have three types of approaches.

Instrumentalism: Women as Producers of Technologies

In the first place, we find a group of investigations centring around questions of how and to what extent women produce technologies. Typically, within this work, there are studies on how low the participation of women is in engineering or other active roles related to the conception and making of devices, and also the historical configurations of this situation (Balsamo, 1996; Becker, 1991; Bradley, 1989; Burfoot, 1999; Caputi, 1988; Cockburn, 1985; Cockburn and Ormrod, 1993; Henwood, 1996; Martin, 1991; Milkman, 1987; Oldenziel, 1999; Oudshoorn, 1994; Suchman, 1995). From this perspective, technology is viewed mostly as a neutral entity, from which women are excluded due to 'social' factors. Thus, the problem lies in studying how the exclusion from technological experimentation occurs

during childhood, at work or in higher education. Though rejecting the assumption of the neutrality of technology, below we inquire into some of the questions raised by this tendency.

Essentialism: Women as Consumers of Technology

Second, there are texts that study how women receive the most varied technological devices (Cowan, 1976; Stanley, 1995). Here technology is usually considered as 'axiologically charged'; that is, loaded with values that are imposed on women. Thus, medical instruments, toys and digital technologies appear as emissaries, either of the patriarchal order, or of its rupture. Expressing this simply, the key point is that here we find the contrary of previous tendencies: women are shaped by and assume roles that are imposed by the technologies with which they interact. Within feminist perspectives, two tendencies—with all their differences—border on this approach: radical feminism and socialist feminism (vid. Wajcman, 2009). In the majority of cases, this relative technological essentialism leads to pessimism. In different forms of feminist heideggerianism, modern technologies are viewed as inexorable tools of male domination (Arditti et al., 1984; Berg, 1997; Cockburn, 1985; Corea et al., 1985; Evans, 1985; McNeil, 1987; Merchant, 1980; Mies and Shiva, 1993; Spallone and Steinberg, 1987; Stanworth, 1987; Wajcman, 1991; Webster, 1989). In other cases, particularly regarding digital technologies, some authors end up with an optimistic perspective (Green and Adam, 1999; Kemp and Squires, 1998; Kirkup et al., 2000). Once again, rejecting the deterministic variants of this approach, we will reengage some of these questions, studying the axiological flows that are crystallised in particular technologies.

Constructivism: Female Gender Co-constructs itself with Technologies

There are also studies which look at how technologies and gender construct each other. Although on a conscious level these perspectives rely on the social studies of technology and science during the 1970s and 1980s (Bijker, Hughes, Pinch, Latour, Collins, etc.), it is important to recall that the co-construction of subjects and objects clearly emerges in Hegel's *Phenomenology of Mind*. This is currently the most widespread tendency. Predictably, it arises from criticising the collaborative silence from non-feminist approaches to the STS field about the gendering of technologies.

We can find two different trends here. The first emerges from the pioneer text that is Donna Haraway's *Cyborg manifesto* (1991). It points not only to the co-construction, but the total hybridisation between nature and technology in gendered *bodies*. This unfolds, first, from a cyber-feminist school, in which cyberspace appears as a field in which the relationship between gender and technology can be reconfigured, taking advantage of the malleability and networked structure of virtual environments (Millar, 1998; Plant, 1998). *Technofeminism* shares several aspects with this perspective, but it is not exclusively related to digital technologies (Faulkner, 2001).

Moreover, some constructivist approaches to gender and technology build on previous STS theories. For instance, Lagesen (2012) developed a theory from actor–network theory (ANT) and Lohan (2000) did so from social construction of technology (SCOT).

The perspective of our study is, overall, akin to that of this third approach, partially because it allows the recovery and transcendence of the previous two. Now, how can we apply this to the specific relation between gender and software production? Instead of reviewing here all the theoretical contributions on the subject, we will try to present them in each section that follows, referring, when appropriate, to the empirical data from our fieldwork, and to the more general contributions reviewed here.

Gendering of Technologies During Early Childhood: Toys and Games

Social tendencies that have the effect of excluding women from informatics activities do not start to mould female subjectivity in college. Neither do they start in adolescence or even during children's first interactions with computers. They appear as early as the first few months of life.

From the moment boys and girls start to bond with the most basic technological devices, they receive all kinds of influences, explicit and implicit, about which are gender-adequate for them, and which are not; about how to relate to them; and how they are expected to put them to use.

In this sense, the first technologies with which boys and girls actively and frequently interact are toys. Incidentally, one of the few things that those on all sides of the debate about the philosophy of technology agree on is that artefacts, far from instrumental neutrality, are imbued with certain values (Feenberg, 1991). Toys are no exception, and in most of them the patriarchal order is objectified without any subtleties. Those values embedded within toys by certain social processes under capitalism, along with adults' instructions regarding games and media influence, result in gender and technology relations being reasonably stabilised before children enter formal education. But before toys and games, it is worth mentioning one important source of role models for boys and girls: cartoons, and more broadly, the media (Colatrella, 2011).

In relation to women's presence in the media, particularly regarding cartoons, studies agree that they appear much less frequently than men, and that when they do appear, women are relegated to secondary roles, stereotyped and removed from narratives of innovation and risk (Eick, 1998). More specifically, inspiring models of women making innovational use of technologies are not detected in any media format. In this sense, and even when it is an indirect factor, it is interesting to address an Australian study that asked teenagers of both genders for examples of women associated with the world of digital technology. Any character could be considered, whether movie-related, TV-related or real. However, 56.2 per cent could not name one single woman—and these were students that had chosen to study information sciences and business (Thomas and Allen, 2006, p. 174). There is room to assume that during early childhood, although not exclusively in

this period, the lack of media transmission of female role models associated with innovative behaviour when using technology might be a relevant factor.

Regarding games—with or without technologies intervening—we find that exploratory and risk related attitudes that shape the approach to science and technology, are stimulated in boys and discouraged in women. For example:

> Young boys often choose to spend their 'free time' running around, exploring, and experimenting, and these activities help them prepare for the world of science and math. Young girls are not specifically encouraged to participate in these 'boy' activities, and are more often encouraged to 'be careful'. (Karahalios and Mujtaba, 2004, p. 151)

Young girls are not specifically encouraged to participate in 'active' activities, and are encouraged to 'be careful' (Swanson, 2000, p. 3).

On top of this, according to a classic work by Maccoby and Jacklyn, the main difference between girls and boys games is that those designed for girls do not present a mental challenge. On the contrary, their main objective is to embed them within stereotypical gender roles. Thus, it is expected of girls to follow the pattern of devoting themselves to repetitive tasks (Maccoby and Jacklyn, 1966).

Finally, regarding the specificity of toys, Starr points out how these have significant differences in terms of relating to technological knowledge.

> The last major difference noticed in boys' toys was the fact that many of their games and building sets encourage higher education and technical skills needed to be successful in dominate career fields. Unlike the girls toys discussed, boys' toys such as, 'The Erector Set', 'Challenge Building Set', 'Deluxe Solar System Set', 'X-Force Put-Together Defense Station', foster them mental stimulation, and teach coordination and problem solving. Through these toys, boys freely explore and experiment, not having to play at home quietly. Many of these toys, in the opinion of Janese Swanson, 'Promote active participation in the outside world, helping to establish a feel for our future world of science and technology'. (Starr, 2000, p. 3)

In a simple investigation, Lisa Wade studied toys from the company Toys R Us, which are different for boys and girls. Apparently, a certain political correctness is maintained, given that when choosing 'styles' for boys and girls, when marketing a toy, profiles of 'techie' or 'adventurer' are included for both genders. However, when we see the real proposals, within the 'techie' category, the differences are notorious. Out of twenty-four recommendations that Wade obtained for each gender, thirteen are aimed at developing 'building/engineering games' for boys, *but just one* for girls. DVD players and other digital technologies are recommended for girls, which are clearly a means of consumption. The author's conclusion is simple: 'Sure enough, Toys R Us confirms that girls may *like* technology, but boys build it' (Wade, 2009).

Thus, it is not so much about boys bonding with the tech world, while girls do not; but about them relating to different technologies, and with different aims. *In our opinion, the most important hypothesis is that the patriarchal order successfully stimulates girls to take on a 'consummatory [7], immediate and closed use of technology, while boys are pushed to develop an instrumental use of those technologies, to explore them, and even, eventually, to break them.* Using a common expression in the field of social studies of science and technology, girls are stimulated to use technology as a 'black box' whose internal processes should not interest them; meanwhile, boys are encouraged to open the black box. As summarised by Swanson: 'Boys invent things; girls use the things boys invent. Boys fix things; girls need things fixed' (Swanson, 2000, p. 3).

First Contact with Digital Technologies: The Videogame Boundary

In this section we set about exploring the first contact that men and women have with computers. We are interested, moreover, in what the most common trajectories are among software producers. Naturally, it can be assumed that looking at these first experiences can help us to observe different paths for different genders. Our fieldwork specifically addressed this subject.

We have found that in the case of men, first contacts happened at relatively young ages, with the arrival of a PC to the family home (in those cases in which age permitted it, that is, to those born around or after 1975) and that the main use given to computers by the interviewees was gaming. Even if there was no computer at home, we found that the first contact with computers was also through gaming, at friends' homes, cybercafés, etc. On the other hand, the appearance of basic programming (with Logo or BASIC, for instance), presented recreational, playful characteristics; especially within the generation that experimented with the emergence of personal computers. The pre-eminence of gaming as a use of computers can be observed in the testimony of our interviewees:

- I don't know, I remember that there was this really old game, which was in code, I mean, you ran the code and it was a game about two monkeys, and you filled in the velocity and angle and they threw each other bananas. So old…and as it was in fact some kind of demonstration for Quick Basic language, it was all code and you ran it. (…). So, looking at that it was like: how do I do something like that? I don't know, nothing complicated, images or lines that swirled in some way, nothing crazy (…) I had a friend who played videogames and it was like—hey, give it to me, I want to play as well! (BA, age twenty-seven, male, programmer, multinational company).
- It was all related to games, mostly. Only in fifth year in high school, there were workshops to choose and I chose informatics, because I knew being in front of the computer was fun for me and that's when I started programming. I programmed, it was fun and well, from there on to college (CGF, male, age twenty-three, State programmer).

On the contrary, for women, we can observe that gaming was not relevant to their first approach to computers. This concurs with some previous studies which agree on the fact that women have a differential approach to technology; gaming is less frequent among them.[8] To support the idea that, at least in the generations concerned here, women played less videogames than men, in the different studies we find the following ideas: (*a*) a differential use from each gender (more functional and collaborative in women, more individual and curious in men); (*b*) the themes that prevail in those videogames (coincidental with male stereotypes); (*c*) the female stereotypes that are included in them (those in which women appear as an object, and very rarely as a subject); and (*d*) the co-construction of gender and women's preference for other activities (Lucas and Sherry, 2004; Roig and Rubio Hurtado, 2009).

Another aspect to be considered is the knowledge that some interviewees seemed to have about the existence of certain games and computer models. This knowledge being previous to the acquisition of such technologies by their family groups, it possibly indicates that this was a topic that circulated among their peer groups. This social characteristic of gaming among boys is present in several studies (Fromme, 2003; Horacek, 2004; Lucas and Sherry, 2004[9]) which also indicate the absence of adults in that micro-world and, on the other hand, characterise boys as expert consumers, holders of a precise and highly strategic knowledge.

Conversely, among girls, it is possible that the type of social interaction related to videogames discouraged those who did feel an attraction to them. Nevertheless this might be better explained by a lack of interest in computers in general rather than a lack of interest in videogames in particular. Conversely, among those girls who do feel an attraction to video games, it is possible that the general lack of playing and low level of diffusion of this social interaction among their peers of the same gender, could have discouraged them.

The key point, although it deserves a more extensive discussion than we can dedicate to it here, is that contact with these games may have generated habits and skills in research and game modification, which emerged from the necessities of gaming, game installation and the handling of computer files and configurations. Hypothetically, these abilities might have configured generic skills that afterwards would have been relevant when choosing the programming career path.

As a matter of fact, within the generations of some of the interviewees many typical games were operated in a similar fashion to basic programming, where code writing resulted in the creation of graphics and sequences. Thus, men that had found videogames attractive would have found a path that women, even those who used a computer for other ends, would not have had the chance to take. Some of the interviewees clearly manifested this transition, which went beyond the action of subordinately playing with specific software; it meant intervening in order to improve the gaming experience or to fix faults produced by game installation. This placed them closer to the threshold of programming.

- I went in and I learned DOS quickly, and I did research too, I liked it. Around six years old, more or less. The first thing I learned was how to run

games. Afterwards well, I created directories, I went in and investigated the best games, the first one was an American football game, then Tetris, Arkanoid… (VR, male, age twenty-six. Market software producer).

- It was about videogames. Videogames and well, afterwards I tried to do stuff to them, modify them, when I was 14, 15 (ML, male, age twenty-seven. Multinational company).

Also, in some cases this gendered transition to programming was taken in order to fix problems, beyond video games.

- So…meddling here, prodding there, maybe you break things and afterwards nothing works. Maybe my dad came and said, 'Nothing works! What did you do?' and somehow you start to see how to fix it, and you start to learn. I mean the part where you see how to fix it…and then you get interested in programming.
  - But what didn't run, for example?
  - Windows crashed because, I don't know, I installed something and it messed up something's configuration. And somehow I had to fix it because if not my dad got mad (BA, male, age twenty-seven, programmer in a multinational company).

The appearance of the Internet also draws a line, with the emergence of chat groups, the possibility of accessing information and also the different programs that allow a social use of the personal computer. These communicational uses are the ones related to the female gender by the common sense, as we have seen before (Bryce and Rutter, 2002).

In any case, it seems relevant that the women who did end up programming have made their approach to the world of computers not through gaming but through the possibilities opened up by social interaction through the Internet and the search for information.

- Doing stuff with the computer, Internet and stuff. I was close to the computer (...) yeah, games, Internet, investigating, reading stuff, I don't know, to learn (MA, female, age twenty-six. Multinational company).
- When I started to use it (I never played any games, they bored me) I used it at first to do schoolwork. I was the only one who typed her homework. A little later the VIVA magazine published something about BBS. While my parents were asleep I went online (TM, female, age twenty-nine. Micro company).

When comparing the approach to computers through videogames and through a communicative use of computer networks, one could think that modifications that ended up developing software skills would more commonly occur in the first type rather than in the latter. Among these possible modifications one can point out the configuration of hardware functioning, installation of drivers and programs,

resolution choice, modification of files, images or data within the game itself.[10] These are all factors that relate to a technical language, which is not utilised in modifications for social networks and instant messaging. Also, social networks and chat programs were at first, and still are, less open to modification. One could hypothesise that they worked more as a means of discussion than as a subject of discussion, although we cannot provide firm grounds for that particular theory here.

In fact for women, the process of greater involvement in the world of programming takes place, our female interviewees told us, at a more advanced age, or in the world of work. Thus taking different trajectories to the one mentioned for men and videogames. So, for women, programming does not seem to emerge due to an amateur or gaming background.

- (This interviewee approached programming through her previous job at a call centre) I stayed in the company but I was moved to systems.
  - And that's when your career started?
  - Yes, kind of, actually I audited networking circuits for Horizon (…) In June, that same year I entered MYB; because I started to study something else. That's when I started to put my career on hold, and studied Oracle and stuff, databases outside college, I was due to go to school in March–April but in June I entered MYB and kept studying that (MA. female, age twenty-six. Multinational company).
- I used to work at a bank, I was a cashier, and during the summer I went to Villa Gessell, as backup staff (…) Over there I was assigned to work on fixed term deposits, and the bank had bought some NCR machines to print the deposits, it was like a big calculator and at the end of the day everything was copied in a diskette and was sent…so when I came back the first year I started to study systems analysis, because I couldn't understand how a machine could do all that (SC, female, age fifty-one. Micro company).

To summarise, we can hypothesise that men and women who belong to the generations we interviewed have had different approaches to computers. For men videogames seem to have played an important role; among women this appears not to be the case. If we add to this the complementary hypothesis which suggests that the bond with videogames might have helped to develop abilities, language and social dynamics akin to those required for programming, one might consider this as a relevant factor to incorporate into the wider explanation of why women are less inclined to become programmers than men.

Of course, the way in which first contact with computers takes place is not enough to explain the significant gender differences among informatics workers.

Differential Socialisation During Adolescence and Puberty

In this section, regarding the profile of software workers and the way in which their activity is learned and engaged, we will consider the period of adolescence and puberty as an important moment. We suggest that is probable that programming

is associated with people who would be willing to spend much of their time in solitude (at least physical solitude) with the computer. That is, those people who become programmers today have shown a particular trajectory in terms of affective and social relationships with their peers. Certainly, this does not imply the absence of those relationships but rather a mode of sociality which differs from hegemonic cultural patterns.

Below we present the characteristics typical of the aforementioned profile, through the representations that our interviewees have of themselves and of their environment, in order to later try to answer how this profile might or might not be entangled with gender.

When responding about how they think they are seen by society, our interviewees answered consistently in a way that distinguishes them clearly from the common pattern: 'weirdos, or the mad scientist look' (ZA, male, age forty-nine, large company manager); 'the nerd stereotype has great influence, you know, working in a dark office with a cactus, artificial light: antisocial, unattractive, no personal life' (SF, male, age thirty-three, programmer); 'Well…the nerd myth prevails' (SC, female, age fifty-one, micro company).

Of course, when being asked about how they think informatics workers really are, this view is discarded and most of our interviewees agree that there are different personalities and profiles, as in any other activity. However, some others go beyond this and say that stereotyped representations actually have some grasp on reality. For example:

- How do you think programmers are seen by society?
  - As nerds, as people that surely work in a basement. (…)
  - And how would *you* describe informatics workers?
  - Like that, only that I know we don't work in a basement, (…) the average informatics worker is square and has no social abilities, and has a hard time getting out of the programming world in general. As always, you can find all types, but the common thing is that if you go out for a cup of coffee with them they will say, 'Hey, did you check out that new version of Linux? It's cool'; and not, 'What was the score in Sunday's match?' (…) Informatics workers are introverted people with zero social skills. I've had pleasant surprises but they have been few (GFC, male, age twenty-three, state programmer).
- Usually developers might be…not as sociable as, I don't know, the rest of the people who are not so into code (BA, male, age twenty-seven, multinational company programmer).

Naturally, these are exceptional cases; however, they reinforce the idea that this representation of informatics workers has a strong hold within society, being present even in workers who are immersed in and familiar with the software world.

Now that we have highlighted these characteristics, let us include gender. As was previously mentioned, the first element that stands out is the social tendency

that assigns roles of communication and cooperation to women (Sanz González, 2006, p. 3); unlike men who are encouraged in the habits of competition and risk, resulting in a greater individual use of technology (Roig and Rubio Hurtado, 2004, p. 3). A second element to point out is that culturally affective relationships seem to be prioritised by the socialised females (what follows is based on Turkle, 1986). So, when the time comes to choose how and where to spend their energies, women usually decline to be part of a world where computers are more important than people. On the contrary, men are more disposed to being 'intimate' with the computer, relying on 'company with no need for friendship' (Turkle, 1986, p. 43). Each gender faces adolescent fears in a different way: men through the dominion of things and flirting with risks; and women through the affective world and community concerns. Thus, for example, the world of hackers is associated with a virtuous male universe and one in which there is an intimate relationship with computers, which represents one of the possible 'escape micro-worlds' of adolescence, chosen mostly by men.

When cross-referencing the representation of informatics workers with the bibliography on gender we can observe that there are different patterns and social pressures in relation to what is expected of the female and male genders regarding certain forms of sociability. In this sense, even if both genders are expected to go through adolescence with a strong presence of peer relationships, leisure and communication, it would seem that a great quantity of time in front of a technological device, when facing the risk of it affecting these social relationships, might be more tolerated for boys than girls, as it is expected of the latter to engage in a more affective and sociable development.

This concurs with our empirical findings, which sustain that for one reason or another, women that actually program have lived their adolescence in a different way than that expected of them through social mandate.

- …I was kind of depressed because I wasn't doing anything, so I started to mess around for two weeks with that game, Image, and I was 20 hours a day at the computer, and afterwards, I don't know, not 20 hours every day but during the day I slept and at night I was playing. And I started researching to do something, to learn, because I was getting more and more depressed because I didn't do anything (MA, female, age twenty-six, database administrator for multinational company).
- I was all the time with the computer (…) I was the computer geek among my friends. 'What do you do with it?' (…) I didn't have the typical adolescence. What my girlfriends always planned, from Wednesday to Saturday night was where to go dancing. I was more of a book girl, when all the moms said, 'Don't go, my mom told me, 'Go out dancing!', and when I went I got bored… (TM, female, age twenty-nine, software micro company owner).

In agreement with what has been said, it is interesting to observe that the presence of women in the software sector (in Argentina) is concentrated in

activities related to communication, design, staff management or administrative tasks (Novick et al., 2008). In this sense, the self-image of informatics workers tends to pay attention only to the world of programming, almost exclusively male, and forgets all the other areas which also operate with digital technologies.

To summarise, gender seems to intervene in a differential manner when related to software production. The experiences of software development during puberty and adolescence (the moment when careers and work choices start to emerge) seem to be marked by a predisposition to solitude with the machine. This kind of predisposition, although not encouraged, is tolerated in the world of male stereotypes. Conversely, it is widely rejected in the dominant representations of women coming from our patriarchal order.

The Gender Gap Within Higher Education

Numerous studies agree in affirming that the student population in informatics in tertiary and higher education at a global level is mainly masculine (Adam, 1995; Camp, 1997; Fernández et al., 2006; Margolis and Fisher, 2002; Sanz, 2008). Even more, in several cases it is observed that this tendency has intensified in the last few years.[11]

In turn, many of our interviewees consider that the gender gap in the student population is an element to consider when explaining the low proportion of women in the labour market. When questioned on reasons for the low rate of female participation in current and previous workplaces, these are some of the answers they gave:

- Because 'scientific knowledge is for men' (ironic tone). Viewed sociologically women study architecture, sociology, humanistic studies; and men study science. Even within engineering careers, when I was little, and a girl went to tech school they said that you were a tomboy, they didn't say lesbian, they said tomboy. It was incomprehensible that a girl would like electronics. They weren't lesbians or anything. There are specific careers for each sex, or gender (SC, female, age fifty-one, micro company programmer).
- I think it happens in college: 30 students, 28 male. The career has more men. Women don't go much into informatics, they don't see it as a work tool, they are educated in.… (GRT, male, partner on micro company).

This argument is reasonable, but only up to a certain point, because the type of degree is not specifically relevant when entering informatics activities (vid. Dughera et al., 2012). In fact, of the four women programmers that we interviewed only one holds a degree (tertiary, and part of a much older generation than that which is dominant in the labour market). The low proportion of women involved in the software productive process and in courses which teach informatics are linked, but they rely on partially autonomous dynamics. On the other hand, women's rejection of following, persisting and graduating in these college careers, has its

roots in factors that extend beyond informatics education. Indeed, factors that we considered previously in this article have already moulded female subjectivity long before women can analyse the benefits and disadvantages that would come from choosing an academic career in computer science. Thus, any discussion regarding the negative relationship between higher education and the female gender must distinguish between these two types of factors: (*a*) factors which *precondition* entrance; and (*b*) factors that emerge from the design, content and dynamics of the career itself. In fact, the previous quotes are related to the first category more than the latter. That is to say, not many internal factors are addressed as factors of exclusion in gender terms.

We do not have sufficient elements to be able to precisely signal the endogenous factors, and doing so would require a specific investigation regarding the course content, students and the social practices of faculty members among other aspects. Despite this, regarding a future inquiry with these characteristics, we can add a few elements that emerge from the literature we have reviewed.

First of all, the low presence of women which, by a vicious circle, would discourage the incorporation of new female students or rather, configure a problem of network externalities. This hypothesis, however, is limited. First, because as said at the beginning of this section, globally, the proportion of women has *decreased* in some countries.[12] Even more, although we do not have precise data on this, during our field work more than once it was mentioned that at the end of the 1970s and the beginning of the 1980s, the female population was much larger in some informatics careers. Therefore, it seems that there are factors that dissuaded women from enrolling on informatics careers *even when previously there were more favourable tendencies*. Second, and in relation to this proportional decline, Veronica Sanz forwards an interesting hypothesis.

> One of the explanations for this phenomenon suggested by some studies in other countries is the importance and prestige that informatics have acquired during those years, because of its strategic role for economic development. It isn't new for feminist science researchers that when a field is incipient many women are encouraged to access it (given that it's still free of gender stereotypes), but as the area grows in prestige more men start to enter and women begin to abandon it, so it ends up turning into an 'old boys club'. (Sanz, 2008, p. 907)

This hypothesis is connected to the increasing mathematisation and formalisation of the discipline. The same author provides a complementary hypothesis. The increase in prestige and scientific rigour would have occurred along with the change in academic qualifications. In many cases, the passage from degrees to engineering qualifications, would have had a psychological impact on women, and would have driven them away from those careers (Sanz, 2008, p. 908).

Third, another Spanish study, which notes a low and declining participation of female students, finds that instead, among doctoral students and professors, female participation is growing (Fernández et al., 2006). The data is valuable since it

suggests that the presence of female professors and doctors either (*a*) does not have a sufficient effect when providing role models for female students, maybe being unattractive stereotypes; or (*b*) is too recent a phenomenon to have an impact on potential students. In any case, if we add to this the fact that *women that do enter the career* do not seem to have inferior academic performances, but even in certain cases superior to that of men, *it would seem that the main difficulty is the initial attraction towards the career.* Actually, in the Spanish universities where her studies are carried out, Sanz (2008, p. 908) finds that the rate of female graduation is noticeably higher than that of male students.[13]

Naturally, to confirm this with greater certainty it would be necessary to study the dropout rates within different countries, among different careers, etc., but the hypothesis remains. Even so, it is helpful to remember, so as not to lose a broad vision of the problem, that a better academic performance does not mean that these women are better received or more productive than men within the labour market.

Regarding the exogenous factors, we can add data from an Australian study on the representations that business and information science students possess. The paper inquired into the social images of men and women as informatics workers, understanding that such imagery would impact on the choice of and perseverance in college careers.

The young women in the study believe, much more than their male counterparts, that (*a*) being interested in computers is not 'cool'; (*b*) those who work in the IT industry are 'nerds'; and (*c*) the informatics industry does not offer good job prospects (Thomas and Allen, 2006, p. 172). The first two ideas appeared over and over again in our field work, when the interviewees were asked to say how they believed they were seen by non-programmers. As opposed to this, the third belief is surprising because of how false it is, at least in terms of income and work conditions in Argentina. Despite these representations being macerated over the years and by media influence, it is clear that the results of the study point out some directions in which universities can battle these symbolic manifestations. Of course, it is not assured that they will be successful in such struggles.

Gender Representations among Employers of Informatics Workers

Finally, the fifth element is that which emerges from the ideas of employers. Even when they only acknowledge it partially, managers in different companies also operate a barrier to the access of women into informatics positions (McKay, 2006). Thus, even when female programmers would have successfully passed through the four stages that we have addressed in previous sections, in some cases the fact of being consciously or unconsciously rejected by personnel selectors or even by their male peers is a relevant factor. This discrimination takes diverse forms. For instance:

- I wouldn't know. Because in general one associates technical stuff with men…For example women in hardware is complicated because there's the matter of physical limitation. (*He points in the map to the place where the*

> *female analyst's office is, his office is adjacent to it*) I employed two new people, but there are some things about the way in which we work that turn women into a limitation. There is the matter of strength, they can't move things. And one wouldn't ask her to put herself on the floor and pass cables. I don't know, maybe it's that (ZA, male, large company manager, in-house production).

So, an idea that is current when rejecting female programmers is that they have limited physical strength. More broadly, this points to tasks that are related to gendered bodies. While the strength argument might be lacking credibility—since there are not many tasks which involve moving hardware, and because male programmers are usually far from being athletic men—the one related to body relations is much more interesting: 'And one wouldn't ask her to put herself on the floor and pass cables'. Here the problem does not seem to be so much physical, but related to the representations of those who see the woman's body lying on the floor: she, herself, and his peers. Our interviewee and others understand that the *image* of the female body requires other postures and other modalities than those expected of or permitted for men. Maybe it is the male discomfort towards women's bodies that deters them from employing them, and not so much the fact that female software workers back out of or are in no condition to do the required tasks.

There is also the following idea: women are not employed because, simply put, men do not know women in the work environment. The men did not work previously with female programmers, and they fear the unknown. In the following quote we can see some of this, spiced with some machismo which is attempted to be camouflaged with the final words.

- The truth is I don't know, I think it is because they are not employed much at work. Because if I'm looking for a worker, it's not that I'm not looking for women, but I've never worked with one before. I'm less willing in advance, because, I don't know…how do they react, I don't know what it is like to work…sometimes they have personal issues…like men…right? (GRT, male, partner in a micro company)

Third, we have the comment made by an interviewee who had employed someone recently. Here the argument is that as it is a micro company in which all three partners are men, being the only woman in such a small productive unit would be uncomfortable *for her.*

- They (the women) applied, not to the interview, but they sent a lot of CVs. But what is the problem? From where I stand, because of the fact that we were three men, it would seem that…, if it was a larger company it would have been different…what happened is that I didn't want to because of that reason…Maybe it's a prejudice on my part, but not for the wrong… I wanted to (*he can't find the words*)
  - *Was it going to be uncomfortable because of the sexual tension?*
  - Yes, yes, I don't know. Not on our behalf, her being the minority

- *So, beyond the CV you took into account the potential discomfort she'd experience at her job?*
- Yes and mostly because of our number, we're really few… (RB, micro company partner)

The explanation is not clear at all, and, as in the other cases, we can see several unsuccessful manoeuvres to conceal gender prejudices. Beyond the aspect that interests us here, these testimonies help us reaffirm what is mentioned earlier regarding the fact that in smaller productive units, the opportunities women have to gain entry into the company are much fewer. Certainly, more explanations could be collected as well as a systematised analysis of employers. For motives of space, we shall stop here, without discarding the possibility that in subsequent investigations we might investigate this factor further.

Conclusion

Through this article we have tried to review the construction of female gender segregation within software productive processes. This is not an easy matter to address. Numerous factors intervene in a combination of ways when configuring this segregation. Our contribution could be summarised through the metaphor of *five concentric rings, five chronologically stratified levels, that combined would construct the segregation we describe*. First, we identified our problem, the contradiction that draws a line between the evolution of gender segregation in the general context of insertion in the labour market and within the software productive processes. In the first section we reviewed how the software sector appears as an anomaly within the evolution of the group it belongs to, informational work. Feminisation observed in the wider context of this kind of occupation is not correspondingly seen in the software world. Even in official figures in Argentina, which only account for large and multinational companies, this disparity indicates that only 34.7 per cent of the employees in the sector are women, and, when inquiring deeper, the gap widens. An even more severe segregation is found in the testimony of our interviewees: around 10 to 1. Finally, this gap widens even more when taking into account other modalities of software production (micro companies, small and medium companies, academic production, NGO's, Free Software, etc.), in which non-registered work (and thus, not considered in official statistics) might have a considerable weight.

The first of the concentric circles we discussed is related to the early childhood of software producers. At such an early stage feminine subjectivity starts to be shaped through the different explicit and implicit influences that define appropriate technologies for each gender, and suitable uses of them. These artefacts themselves have certain embedded values, so that in toys we already see the persistence of the patriarchal order in the design, the accompanying instructions, the mediation of adults in games and, last but not least, media influence. All this informs us that gender roles are already partially stabilised a long time before children access

the formal education system. In the section dedicated to this matter, based on our theoretical analysis we find that already in early childhood women are discouraged from exploration and experimentation, and on the other hand, games that are offered to them involve a high level of repetition, and are always intended to stabilise current gender stereotypes. Once again making use of previous literature we look at how, regardless of political correctness implied in different categories of toys for both genders, the companies, when designing toys, differentiate between male and female profiles, giving women the role of *technology consumers*, and not the role of *technology constructors*. Therefore, what we find is that during childhood a consummatory, immediate use of technology is stimulated for girls, unlike the instrumental and exploratory use that is encouraged among boys.

The second concentric circle consisted of a review of the first contact that programmers had with computers, and their entrance into the programming world. Based on the collected testimonies and also previous studies, we were able to see the preponderant role of videogames in the first experiences of computer use for our male interviewees, while women did not demonstrate this use. We found that in this generation of programmers, in many cases games implied a differential approach to software later on, when trying to modify and adapt them. Considering this differential relationship with games, women lose one of the paths to a potential deepening of their relationship with computers. The prevalence of functional type uses (word processors, listening to music, searching for information, school work, etc.) encountered among women seems to define their initial interactions with computers. Also, the first approach to programming is produced generally during childhood and adolescence in boys. On the contrary, in the case of our female interviewees, the first approach was much later on, with their work career already in motion.

The third circle refers to the period of puberty and adolescence. There, through the observation of the representation of informatics workers, which is anchored in society, we highlighted first, that software production required the willingness to spend a lot of time in front of the computer. This can be observed indistinguishably in both genders. However, the culturally expected management of time and adolescent sociability is very different for both genders. More precisely, this type of intimate relationship with the machine combined with the stereotype of the lonely programmer, is more tolerated for and by men than for and by women, who are expected to have a greater interest in affective bonding and communication in general. In agreement with this, the female programmers we interviewed have demonstrably lived their adolescence in a different manner than their peers.

The fourth concentric circle is the one related to insertion and development at university. Reluctance to enter these kinds of careers is widely related to factors that are beyond informatics education itself. In this sense, the low presence of women is a genuine discouragement, but not a sufficient one. This can be seen in the recent decline of female rates, and also in the fact that in our fieldwork we found that in previous decades (the 1970s and 1980s) the proportion of women was higher than present.

Therefore, the previous existence of more favourable tendencies indicates, in turn, the existence of other factors which counteracted them. Following Veronica Sanz we mentioned the hypothesis that when academic fields are incipient, women are more encouraged to take part in them, but as the field becomes more formal, and mathematical, as its prestige grows female involvement decreases.

Additionally, women demonstrate that interest in computers is not 'cool', they confirm the stereotypical perception of programmers as nerds, and surprisingly, define career opportunities as poor within the informatics field.

Finally, the fifth concentric circle is the one that emerges from the representations of employers. Although they only acknowledge it partially, managers of different companies also operate by blocking women's access to informatics jobs. Even when female programmers have overcome the other four obstacles previously described, which are related to the supply of female informatics workers in the labour market, the fact that they are consciously or unconsciously rejected by staff selectors (and even male peers) acts as a relevant factor. We have seen that this discrimination takes diverse discursive forms: (*a*) that women cannot engage in the physical tasks that the activities require or that their bodies are disruptive; (*b*) that men do not have experience in working with women, and therefore do not want to risk taking on an unpredictable factor; and (*c*) that in a highly masculine environment, selectors say that women would not feel comfortable.

To conclude, it is necessary to say some words regarding possible public policies. Next we list some recommendations for each of the concentric circles:

1. Early childhood:
   - Media: encourage the incorporation of women into innovative roles.
   - Create incentives for toy manufacturers or marketers to offer products that stimulate a bond between girls and technology.
   - Teachers/Education: encourage girls to participate in games related to innovation, exploration etc.
2. First contact with computers:
   - Level out the playing field for boys and girls in the timing and quality of their first contact with technology.
3. Puberty and adolescence:
   - Challenge the myth of the nerd that stereotypes programmers.
   - Promote female role models in informatics.
4. Higher education:
   - Create grants specifically aimed at women in universities and research councils.
5. Employers:
   - Establish incentives—or penalties as the case may be—for employers, to encourage the hiring of women in the SIS sector.

Throughout this study we have reviewed a cluster of different influences that act upon women to determine a differential approach to technology and computers, and which also help to explain the effective gender segregation we observe in our

fieldwork. The breadth of these factors opens new possibilities for investigations to look into each of them specifically and allow a more exhaustive explanation of each. The fact that generational experiences have an expiration date, demands of us to think and inquire into the experience of the new generations, who inhabit a radically different world (concerning their relationship with digital technologies) than the one which framed the experiences analysed here. It also requires us to think about the effects that these new experiences will have on the configuration of the programming field and of gender itself.

NOTES

1. A preliminary version of this article was presented at the 10th Globelics International Conference (The Global Network for the Economics of Learning, Innovation, and Competence Building Systems), Hangzhou, China.
2. The central aspect of our fieldwork consisted in the realisation of interviews based on a non-probabilistic sample of twenty-five cases. Between September and December 2010, twenty-four interviews took place along with an interview with a key informant. The sample was intentional and the main criterion for it was theoretical saturation, in order to cover the heterogeneity of the sub-sector.
3. The present study is part of a wider investigation framed by the UBA Social Sciences Faculty's Institutional Recognition Project, R10-279.
4. In this area, the income gap is what relegates women: it reaches 46 per cent, the highest among the studied sectors (Castillo et al., 2008, p. 70).
5. Malaysia offers an interesting exception to this pattern. See Mellström (2009).
6. More broadly, there are relevant studies regarding the relationship between science, technology and gender. See Wyer et al. (2013).
7. We utilise the term from Talcott Parsons (1970).
8. Nevertheless, there are some more recent studies that indicate that within 'digital natives' (a population which our interviewees are not part of) there would be a population of users with a proportional equality of men and women (Bryce and Rutter, 2002).
9. This study shows how, in a gratification source scale, social interaction is one of the most important among men.
10. This can be seen, for example, in the existence of communities that occupy themselves with altering the content of sports games in order to adapt them to the local leagues and costumes (http://www.afa-pes.com.ar, http://www.fifabolivia.com, http://www.pesconmebol.com, http://pespasionarg.foroes.net/, etc.)
11. For instance:

    > The percentage of women gaining degrees in computing in the United States went down from 32.5 per cent in 1980 to 28 per cent in 2000 (Camp, 2002). In Australia, the percentage of women enrolling in IT courses has dropped from 48.1 per cent in 1994 to 32 per cent in 2003 (Lang and Hede, 2004) and dropped to 21.97 per cent in 2005 (O'Keefe, 2005). (Thomas and Allen, 2006, p. 166)

    Additionally, an interesting account of the trend can be found in Light (1999).
12. We could add to the previous note, that a Spanish study suggests a decline in informatics that, surprisingly, contrasts with the increase of female participation in general technical careers (Fernández et al., 2006, p. 1).
13. In this sense:

    > This data contradicts the popular idea that women have worse results than men in informatics, as it is considered generally for all the technique disciplines and also mathematics. Most of the professors who were interviewed mention that female students are more devoted to their work than men, and usually obtain (on average) better results when referring to qualifications. (Sanz, 2008, p. 908)

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