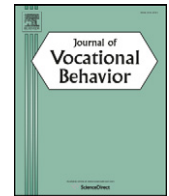


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Journal of Vocational Behavior

journal homepage: [www.elsevier.com/locate/jvb](http://www.elsevier.com/locate/jvb)

## Self-concept of computer and math ability: Gender implications across time and within ICT studies

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### ARTICLE INFO

#### Article history:

Received 18 April 2011

Available online xxxxx

#### Keywords:

Gender

Math ability

Computer ability

Math performance

ICT studies and achievement

### ABSTRACT

The scarcity of women in ICT-related studies has been systematically reported by the scientific community for many years. This paper has three goals: to analyze gender differences in self-concept of computer and math abilities along with math performance in two consecutive academic years; to study the ontogeny of gender differences in self-concept of computer and of math abilities and math performance across subject areas; and to contrast the role these variables play in predicting ICT-related studies over 2 years. 900 ( $M = 15$  years,  $s.d. = 1.73$ ) and 424 ( $M = 16$  years,  $s.d. = .49$ ) Spanish secondary students participated at both times. Self-concept of computer ability is higher in boys at both times; furthermore it decreases in girls and increases in boys across time. At time 2, boys have a higher self-concept of math ability, despite the lack of gender differences in math performance. Participants have a higher self-concept of math ability and math performance at time 1 than at time 2. Self-concepts of computer ability predict the intention to pursue ICT-related studies and mediate the association of gender with the intention to pursue ICT-studies.

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### 1. Introduction

Boys are more likely to develop an interest in the physical sciences and engineering than girls; in contrast, girls are more likely to develop an interest in biological and social sciences, languages and reading than boys (Eccles et al., 1998). These different preferences in boys and girls become more intense during the secondary school years, the time in life when adolescents must choose school subjects and academic paths. Several studies have shown that such choices are influenced by such psychological factors as their hierarchy of interests, ability self-concepts and domain specific self-efficacy beliefs, and the perception of costs and benefits of getting involved in different activities (Bandura, Barbaranelli, Caprana, & Pastorelli, 2001; Deci & Ryan, 1985; Eccles, 1994; Eccles & Wigfield, 2002).

International researchers have systematically reported that women are more likely than boys to aspire to careers in health and biology-related careers. In contrast, men are more interested in pursuing scientific and technological studies and less interested in studies related to the provision of care and nurturance (Eagly & Wood, 1999; Eccles, 1983; 2007; Kiefer & Shih, 2006). In the Spanish context, technological studies are prestigious because, among other different aspects related to their inherent work opportunities, they are associated with high intellectual capacities and are very difficult to enter because they require high academic performance in technological and scientific domains, such as math, physical science or technology (López-Sáez, Puertas, & Sáinz, 2011). For this reason, some authors have analyzed why girls are not as interested as their male counterparts in pursuing these challenging and highly prestigious studies, despite having good academic qualifications to obtain admission in them (Eccles, 2007; Eccles, Barber, & Jozefowicz, 1999). Those students who are not good at those technology-related domains or perceive that they are not competent enough at those domains (like women) may not choose them, even if their real performance in those domains is not as low as they perceive it to be (Bandura et al., 2001; Eccles, Adler, & Meece, 1984).

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### 1.1. Factors explaining the lack of female enrollment in science and technology-related studies

Mathematical abilities are considered a prerequisite for those students wanting to enroll in technological studies and those who want to gain admission to the related college majors and professional occupations (Meece, Eccles-Parsons, Kaczala, Goff, & Futterman, 1982). For this reason, those students excelling in math-related subjects in secondary are the ideal candidates for advanced technology and science related degrees. It has long been argued that boys are more likely to have mathematical talent than girls while girls are more likely than boys to have verbal talent, leading boys to do better in mathematics than girls, to develop high math ability self-concepts, and to be more likely to enter math related technical fields (Eccles et al., 1998; Guimond & Roussel, 2001; Skaalvik & Skaalvik, 2004). However, the validity of this explanation has been called into question by the meta-analytical research of Hyde, Fennema, and Lamon (1990). These authors found little support for the assumption that boys, on average, demonstrate higher mathematical abilities than girls.

The most recent PISA report published (OECD, 2010) shows that the girls, on average, performed somewhat worse than males in mathematics in many countries, but the advantage of males in those countries where this difference exists was mainly due to the very high levels of performance of a comparatively small number of males. Overall, gender differences in mathematics were less than one-third as large as for reading, 12 points for mathematics versus 39 points for reading on average across OECD countries. This pattern has not changed since PISA 2003. The lack of interest of boys in reading has an impact on their perception of their own reading abilities and the choice of studies. As a result, boys are less likely than girls to pursue these studies and therefore remain underrepresented in these fields (Kiefer & Shih, 2006).

More recent research supports the gender similarities hypothesis assuming the existence of more psychological similarities than differences between men and women in different domains and abilities (Hyde, 2005; Hyde & Linn, 2006). Nonetheless, the context can create, minimize, or increase the effect of psychological gender differences (Bussey & Bandura, 1999; Eagly & Wood, 1999; Hyde, 2005). In this sense, there is also evidence on how cultural and situational contexts can exacerbate the magnitude of gender differences in academic performance (Eccles, 1983; Hyde & Linn, 2006; Meece et al., 1982). In addition, according to the theory of Stereotype Threat women may perform less well than men on standardized tests (such as SAT-Math or the PISA math test) not because they have less math ability than men but because of the anxiety produced by stereotype threat (Spencer, Steele, & Quinn, 1999).

Despite the fact that the gender differences when present favor males on competitive tests of math ability, girls in general get better grades than boys in mathematics courses and the proportion of females majoring in mathematics per se (rather than the physical sciences, engineering and technology) matches that of males in some countries, such as the USA (Jacobs, Lanza, Osgood, Eccles, & Wigfield, 2002). For example, in Spain women made up 50.09% of the undergraduates seeking a university degree in Mathematics in 2006–2007 (Instituto de la Mujer, 2010). This pattern of equal participation of women in the university degree of mathematics has remained constant for more than 10 years ago. Thus, it is not clear that mathematics per se is stereotyped as male. Early studies in the USA, for example, found that mathematics was one of the least gender-stereotyped subject areas (Huston, 1983). More recent studies suggest that most children, particularly girls, indicate that neither boys nor girls are more likely to excel in mathematics (Ruble, Martin, & Berenbaum, 2006). So perhaps it is not the stereotype of mathematics per se that is negatively influencing girls' performance on tests of mathematical skills, but rather stereotypes associated with the physical sciences, technology, and engineering.

In support of this suggestion, research provides ample evidence that women consider themselves less competent in technology-related domains (despite their high performance in these domains) and that this belief can deter them from participating in technology-related studies (Creamer, Lee, & Meszaros, 2006; Eccles, 2007). For this reason, both between and within individual differences in self-perception of domain abilities are very predictive of which academic subjects individuals are likely to pursue (Deci & Ryan, 1985; Eccles, 1983; 1987; Marsh & Yeung, 1997).

The Expectancy-Value Model of Achievement Choices formulated almost 30 years ago by Eccles-Parsons et al. (1983) continues to be one of the most prominent motivational theoretical frameworks in which both self-concepts of domain ability and the subjective task value attached to various achievement-related choices play a major role in the explanation of motivational factors leading to behavioral outcomes, like the choice of studies and careers. These authors suggest that individuals' achievement-related choices are directly influenced by expectation of success and subjective task value (Eccles, 1987; 1994; Eccles-Parsons et al., 1983; Wigfield & Eccles, 2002). Therefore, individuals may value more those tasks at which they think they can excel than those tasks at which they are unsure about the likelihood of success and for this reason they may be more likely to enroll in courses and studies that they think they can master and that have a high task value for them.

The model links achievement-related beliefs, outcomes and goals to interpretative systems like causal attributions, to the input of social agents (e.g., parents, teachers, siblings, peers, and media), to various social-role related beliefs, to self perceptions and self concept, and to one's perceptions of various tasks, behaviors and activities themselves (Eccles, 2007). Hence, self-concepts of domain-specific abilities result, at least in part, from the feedback provided by other significant people. The influence of family, school, peers, mass media and immediate social environment shapes men and women's self-concept of their own abilities together with the value they attach to various subjects and academic domains (Eccles, 1994).

Encouragement received from other significant people (family, schools, peers and others) to pursue math and technology-related studies plays a major role in whether adolescents decide to pursue a career in those domains or not (Bandura et al., 2001; Eccles et al., 1999; Hackett, 1999; Sáinz et al., 2009; Zarett, Malanchuk, Davis-Kean, & Eccles, 2006). In this sense, self-concept of math ability has been considered a crucial factor in the analysis of the lower participation of women and other minorities in math-related studies (Eccles, 1984; Hyde et al., 1990). Gender differences in self-beliefs mediate gender differences in selected achievement behavior (Fredricks & Eccles, 2002).

The notion of self-concepts of domain-specific abilities is quite similar to Bandura's self-efficacy construct (Wigfield & Eccles, 2002). Thus, Bandura's social cognitive theory has been also applied to career behavior and more specifically to the prediction of interests and choice goals in science and engineering related disciplines with high school and university students from different international backgrounds (Hackett & Betz, 1981; Lent, Lopez, Lopez, & Scheu, 2008; Lent, Paixão, Silva, & Leitão, 2010, among others). Like the Eccles et al. Expectancy-Value Theory of Achievement-related Choices, Self-Efficacy Theory posits that the person plays an active agent in shaping his or her career directions (Hackett, 1999). Early learning experiences influence not only the individuals' personal interests and motivation, but also their self-efficacy expectations. These self-efficacy expectations refer to the beliefs or convictions that one can successfully perform a task, which plays a key role in the self-regulation of motivation and gender-linked choices (Bussey & Bandura, 1999). For this reason, mastery experiences are considered powerful contributors to the development of a strong sense of personal efficacy.

Some social cognitive theorists provide evidence on how career efficacy beliefs play a more powerful role than interests, values and abilities in the restriction of women's career choices (Hackett, 1999; Hackett & Betz, 1981). "Traditionally feminine sex-typed experiences in childhood often limit women's exposure to the sources of information necessary for the development of strong beliefs of efficacy in many occupational areas" (Hackett, 1999, p. 234). In this sense, the self-efficacy theory also provides a heuristic framework for understanding the cognitive and affective mediators of women's gender role socialization experiences and the resulting gender differences in career choices (Hackett & Betz, 1981).

Boys usually report higher expectations for success and abilities in stereotypically male domains (such as math, physical science and sports) than girls, while girls report higher perceptions of their verbal skills than boys (Skaalvik & Skaalvik, 2004; Wigfield & Eccles, 2002). In addition, women tend to overestimate their own skills for typically feminine tasks and men overestimate their own skills for typically masculine tasks; however men are more prone to this type of bias than women, which may account for why males report higher math ability self-concepts than females despite the fact that women actually get better grades in math courses than males (Eccles et al., 1984). Eccles (1994) also highlighted the importance of comparing not only the self-concept of girls to the self-concept of boys, but the importance of comparing girls' and boys' hierarchical rankings of their own domain specific self-concepts. Eccles et al. assume that it is the within-person relative ratings of one's own abilities across subject areas that are key to educational decisions. Girls may be less likely than males to select physical science and technology careers because the girls think they are better at verbal skills and biological science skills than they are at physical science and technology skills rather than because they rate their math skills lower than the boys rate theirs. In support of this suggestion, Eccles and Harold (1992) found that among gifted students, girls reported higher ability self concepts for reading than math, while the gifted boys reported higher ability self concepts for math than for reading. Furthermore, the girls didn't report a lower self-concept of math ability than the boys. Nonetheless, the girls were less likely to aspire to careers in math-related technical fields than the boys. Unfortunately, few studies have pursued this line of argument focusing primarily on the gender difference in math ability self concepts rather than on within-individual relative perceptions across subject areas.

Instead, research has typically associated the gender difference in students' interest in getting enrolled in scientific and technological studies as analogous to the gender differences in students' self perception of math ability (Eccles, 1984; 1994; 2007; Guimond & Roussel, 2001; Hackett & Betz, 1981; Kiefer & Shih, 2006). Girls' low perception of their ability in mathematics has been found to be a mediator of the gender difference in students' enrollment in math-related studies and careers (Eccles, 1994; Hackett, 1999). Nonetheless, research on the field of computer science and ICTs is less abundant than the one related to the math-related field. Some recent studies attempt to analyze why girls are reluctant to pursue ICT-related studies (Sáinz et al., 2009; Singh, Allen, Scheckler, & Darlington, 2007; Zarrett & Malanchuk, 2005).

In this sense, empirical research demonstrates that women think that they are less competent than their male counterparts in computers (Sáinz et al., 2009; Zarrett & Malanchuk, 2005), despite objective evidence of equal or superior academic performance by females (Singh et al., 2007). Girls' lower perception of computer ability explained girls' lack of interest in pursuing IT-related careers (Lent et al., 2008; Sáinz, 2007; Zarrett et al., 2006; Zarrett & Malanchuk, 2005). In this regard, the study of gender differences in computer attitudes has drawn the attention of most studies carried out within the field of computer science, proving that women hold more negative attitudes about computers than their male counterparts (Sáinz, 2007; Whitley, 1997). These negative attitudes towards computers deter women from pursuing computer-related studies and careers (Sáinz & López-Sáez, 2010).

The stereotypical beliefs about men's higher potential performance in mathematical and technological abilities are likely to exert negative pressure on women in order to conform with these gender norms (Kurtz-Costes, Rowley, Harris-Britt, & Woods, 2008). Girls may believe that their math talent is lower than it actually is, despite their good performance in math and science, perhaps because they have been taught to be modest and to attribute their mathematical successes to hard work rather than talent. Boys, on the contrary, brag about their relative success in math (Guimond & Roussel, 2001) and have been shown to overestimate their math ability (Eccles, 1994). *Social identity theory* postulated by Tajfel (1974) argues that people tend to associate themselves and others according to different social categories (gender, age cohort, classroom level, etc.) and that intergroup comparison plays a major role in self-evaluation and for this reason these gender stereotypes will have an impact in the way men and women evaluate their own abilities. Evidence supports this suggestion: females endorse the stereotype that men are better at math and like math more than women (Eccles, 2011).

### 1.2. The ontogenesis of self-concept of domain ability and achievement

As self-concept of domain-specific ability changes over time (mostly among children and adolescents), different studies have attempted to analyze the ontogeny of these ability self-concepts over time (Eccles, 1987; Fredricks & Eccles, 2002; Jacobs et al.,

2002; Marsh & Yeung, 1997). On average, ability self-concepts in math, reading, and sports decline as children get older (Eccles, 1987; Fredricks & Eccles, 2002), reflecting in part a process of social comparison as the school setting gets more and more competitive (Eccles, 1984).

But when do gender differences emerge? The empirical research has yielded inconsistent findings. Early research reported that gender differences in competence beliefs emerge gradually over time (Wigfield et al., 1997). Concretely, cross-sectional and short-term longitudinal research found that gender differences appear to emerge during early adolescence and grow larger during adolescent years (Eccles, 1987). Consistent with these studies, Whitley's (1997) meta-analytical study on gender differences in computer attitudes found the largest differences among high school students and the smallest differences among grammar school students. Such results are consistent with predictions inherent in gender identification and gender role socialization theories. For example, gender identification theory assumes that gender differences will be maximal during the early puberty years when boys and girls have a high interest in carrying out activities congruent with gender roles (Hill & Lynch, 1983). Similarly, according to gender socialization theories, adolescents are likely to be most encouraged by their families, schools, peers or mass media to behave congruently with gender roles (Eccles, 1987; 2007; Whitley, 1997; among others).

In contrast, some of the more recent research in the USA has documented quite marked gender differences among early elementary school students and some convergence in the scores of females and males over the high school years for ability self-concepts (Jacobs et al., 2002). This finding is consistent with other studies showing no age related changes in the magnitude of gender differences in academic self-concepts (Marsh & Yeung, 1997). However in this same sample as used by Eccles, Wigfield, Harold, and Blumenfeld (1993), although both boys' and girls' interest in mathematics declined in high-school, this decline was stronger in girls than in boys (Jacobs et al., 2002). Finally, the developmental patterns of for gender differences vary across subject areas (Fredricks & Eccles, 2002; Jacobs et al., 2002). Most studies, however, have been done within the USA, within the last 20–30 years, and on a limited range of topics. Thus we do not know how generalizable these findings are.

### 1.3. Main aims and hypotheses to be contrasted

Based on our review of the literature, we have the following objectives and aims:

1. To analyze gender differences in self-concepts of math and computer ability together with math performance at two different moments: when participants are enrolled in the last course of ESO (compulsory secondary education) and in the first course of *Bachillerato* (the first course of high school). The interrelations between the different variables together with the moderating the gender effect on the domain of *Bachillerato* chosen will be also analyzed.
  - We predict that girls will report lower self-concept of computer and math abilities and lower math performance than boys, at both at time 1 and at time 2.
  - Additionally, we predict that students' computer and math ability self-concepts will differ depending on the specific course they select at *Bachillerato* with students (mostly boys) in the Technological *Bachillerato* reporting higher self-concepts of math and of computer ability along with higher math performance than students who chose the other *Bachilleratos* (especially girls).
2. Our second objective is to analyze changes in the students' self-concept of math ability and self-concept of computer ability and math performance from time 1 to time 2.
  - We hypothesize that adolescents will have a higher self-concept of their own ability in math and in computer, together with in math performance at time 1 than at time 2 and that the decrease over time will be higher in girls than in boys.
3. Our third objective is to examine the role played by self-concept of computer and math ability along with math performance in predicting students' intention to pursue ICT-related studies at times 1 and 2, together with the analysis of the role played by gender in the choice of ICT-related studies.
  - We expect that self-concept of computer ability is a better predictor of the intention to pursue ICT-related studies than the rest of constructs at both times.
  - We also predicted that the gender difference in self concept of computer ability will mediate the gender difference in intentions to pursue ICT-related studies.

## 2. Method

### 2.1. Sample

The sample at time 1 is comprised of 900 students enrolled in the fourth course of ESO with a mean age of 15 years ( $s.d. = .70$ ). 50.7% of the participants are girls. Similarly, the sample at time 2 is composed of 775 students enrolled in the first course of *Bachillerato* with a mean of age of 16 years ( $s.d. = .62$ ). 57.5% of the participants are women. However, only 52.4% (424) of participants took part at both time points and these 424 students constitute the sample for this paper. 56.3% of these students are girls. 55.6% of those 424 students are enrolled in Scientific and Technological *Bachillerato*, 42.3% in the Humanistic and Social Scientific *Bachillerato* and 2.1% in the Artistic *Bachillerato*. A higher percentage of the boys than of the girls are enrolled in the Scientific and Technological *Bachillerato* (29.24% of boys in contrast to 25.94% of girls), while a higher percentage of the girls are enrolled in the Humanistic and Social Scientific *Bachillerato* (28.3% girls in comparison to 13.68% boys). All participating high schools are public (10 in total). Students in this

longitudinal sample come mostly from urban areas (60.4%) and intermediate socioeconomic status (67.5%). 89.4% of the participants have Spanish background.

## 2.2. Procedure

The contact procedure was carried out by the research team who collaborated with teachers working in the different high schools and the management team at the beginning of 2008–2009 and 2009–2010 academic years and after prior authorization to carry out the study by the managerial team and parents of students. Participants were encouraged to answer all questions accordingly to their opinions and general instructions on how to answer the survey properly along with general objectives of the study were presented.

The survey was delivered during lesson hours in order not to interfere with the academic daily life. Both anonymity of the participants and confidentiality of the data to be collected were guaranteed. At the beginning of the survey, in order to carry out a proper follow-up of the participants across both measures and to guarantee participants' anonymity, students were requested to answer some questions in order to fill in an identification code through which identify participants in both times.

## 2.3. Measures

The scales were standardized prior to the analysis of data and a factor analysis with varimax rotation was carried out in order to confirm that the items saturated correctly in the same scale. In general terms, the scales have good reliability indexes. The standardization was carried out calculating the Z scores of all the measures and then multiplying these scores by 10 and adding 50.

### 2.3.1. Self-concept of computer ability scale

This scale is based on the translation of a scale reported by [Zarrett and Malanchuk \(2005\)](#). It consists of 5 items with values between 1 – not at all good at computers and 7 – *very good at computers*. Sample items read as follows: “I am good at computers” or “How good do you think others think you are at computers”. Self-concept of computer ability refers to self-perception of one's ability with computers. Reliability index = .85. Bartlett's test of sphericity is statistically significant.  $X^2(10) = 2.494,316$  ( $p < .001$ ). Kaiser's measure of sampling adequacy was 87. The factor accounts for 71.46% of the total variance.

### 2.3.2. Self-concept of math ability scale

This scale was based on the translation of the scale reported by [Eccles and Harold \(1991\)](#). It consists of 4 items with values between 1 – lower value indicating low competence and 7 – higher value indicating high competence. Sample items are as follows: “In comparison to other subjects, how good you are at math” or “I would like to be better at math”. Self-concept of math ability refers to the perception of one's ability in math. Index of Reliability = .80. Bartlett's test of sphericity is statistically significant  $X^2(10) = 2244,670$ ,  $p < .001$ . Kaiser's measure of sampling adequacy was 83. This factor accounts for 61.48% of the total variance. Similar scales have been used in many previous studies in English speaking countries and have been shown to have excellent psychometric properties and high face, predictive, convergent and discriminant validity (e.g., [Eccles et al., 1984](#); [Jacobs et al., 2002](#); [Wigfield et al., 1997](#)).

### 2.3.3. Math performance scale

This scale was developed for this project and consisted of one item with 5 options where students reported the final grade they had obtained in the last math course they took. Answers range between 1 – the lowest value, equivalent to Fail and 5 – the highest value, equivalent to Excellent.

### 2.3.4. Intention to pursue ICT related studies in the future

Participants were asked to what extent they plan to enroll in ICT studies when they think about their future professional path. Those who planned to study ICT studies were assigned a 1 and those who didn't have the intention to pursue ICT studies were assigned a 0. Students were also requested to choose between the two types of ICT degrees they would like to pursue in the future: Computer Science and Telecommunications Engineering.

## 3. Results

### 3.1. Descriptive analysis

As observed in [Table 1](#), the global means at time 1 and time 2 for all variables are quite similar. But males scored higher than females in both self-concept of computer ability and self-concept of math ability at both times, despite the fact that the females reported higher math performance than the males at time 1. Although the males scored slightly higher than the females at time 2, this difference was not statistically significant [ $t(1) = .087$ ,  $p > .05$ ]. Across time, the males' score in their ability self-concepts for math and computer ability and their reports of their math performance increased from time 1 to time 2. In contrast, the females' scores declined slightly.

**Table 1**

Means and standard deviations for general sample and for women and men at time 1 and time 2.

Variables	Time	M		s.d.		M		s.d.		Ttest
		Global sample		Women		Men				
Self-concept of computer ability	Time 1	49.99	10.02	48.58	10.32	51.44	9.51	4.280***		
	Time 2	49.94	10.02	48.26	10.04	52.23	9.54	4.796***		
Self-concept of math ability	Time 1	50.00	10.00	49.79	10.23	50.20	9.78	.614		
	Time 2	50.02	10.04	48.47	9.95	52.11	9.63	3.527***		
Math performance	Time 1	50.17	10.09	50.97	10.08	49.35	10.04	-2.403***		
	Time 2	50.51	9.63	49.75	9.97	50.07	10.09	.087		

\*\*\* p < .001.  
 \*\* p < .01.  
 \* p < .05.

3.2. Correlations

At time 1 and time 2, correlations between self concept of math ability and perceived math performance were relatively high and positive (see Table 2). Nonetheless, self-concept of computer ability correlated negatively with math performance at both times. Correlations between self-concept of computer ability and of math ability were not statistically significant. At times 1 and 2, correlations between the two types of self-concepts were not significant for either males or females (see Table 2). In addition, correlations between self-concept of computer ability and math performance were negative and significant for girls. For girls, the higher grades in math, the lower their perception of computer ability. However the gender differences in this relationship were not statistically significant at either time 1 ( $Z = -.30$ ) or at time 2 ( $Z = -1.83$ ). Nonetheless, correlations between self-concept of math ability and math performance were quite high and significantly positive for males and females: the higher self-perception of math ability, the higher the math grades. It is worth mentioning that correlations between self-concept of math ability and math performance were higher for boys than for girls in both times. However, this difference was only significant at time 1 ( $Z = 2.08$ ), not at time 2 ( $Z = .40$ ).

3.3. Objectives 1 and 2: variations in the gender differences in all constructs across time and subject area

Concerning the ontogenesis of gender differences in self-concept of computer ability, a 2 (gender) × 2 (time) repeated measures ANOVA shows a significant interaction effect of gender × time on self-concept of computer ability [ $F(1,413) = 6.137$ ,  $p < .01$ ;  $\eta^2 = .01$ ]: young men's self-concept of computer ability increased from time 1 ( $M = 51.63$ ;  $s.d. = 9.16$ ) to time 2 ( $M = 52.91$ ;  $s.d. = 8.85$ ). In contrast, young women's self-concept of computer ability decreased from time 1 ( $M = 49.05$ ;  $s.d. = 9.88$ ) to time 2 ( $M = 48.33$ ;  $s.d. = 10.34$ ). As a consequence, the gender difference is larger at time 2 than at time 1 (see Fig. 1). There is also a significant main effect for gender on the self-concept of computer ability [ $F(1,413) = 17.190$ ,  $p < .001$ ;  $\eta^2 = .04$ ] with the young men ( $M = 52.91$ ;  $s.d. = 9.16$ ) reporting higher ratings than the young women ( $M = 48.69$ ;  $s.d. = 9.88$ ).

With regard to self-concept of math ability, participants reported significantly higher self-concept of math ability at time 1 ( $M = 52.27$ ) than at time 2 ( $M = 50.32$ ) [ $F(1,420) = 10.400$ ,  $p < .001$ ;  $\eta^2 = .08$ ]. The young men ( $M = 52.73$ ) reported higher self-concepts of math ability than the young women ( $M = 49.86$ ) [ $F(1,420) = 40.147$ ,  $p < .001$ ;  $\eta^2 = .02$ ]. The gender × time interaction was not statistically significant [ $F(1,420) = 1.377$ ,  $p > .05$ ].

Finally, the 2 (gender) × 2 (time) repeated measures ANOVA yielded a significant main effect of time for math performance. Participants reported a better math performance at time 1 ( $M = 53.88$ ) than at time 2 ( $M = 50.53$ ); [ $F(1,417) = 72.388$ ,  $p < .001$ ;  $\eta^2 = .15$ ]. Neither the main effect of gender [ $F(1,417) = .020$ ,  $p > .05$ ] nor the interaction of gender × time was statistically significant [ $F(1,424) = .104$ ,  $p > .05$ ].

On the other hand and with reference to the moderating role across time of the subject area in gender differences in self-concept of computer ability, the 2 (gender) × 2 (time) × 3 (track of *Bachillerato*) ANOVA yielded a main effect of gender on self-concept of computer ability [ $F(1,406) = 5.297$ ,  $p < .02$ ;  $\eta^2 = .01$ ], with boys ( $M = 53.06$ ) reporting a higher self-concept of

**Table 2**

Zero order correlations between variables in the global sample and by gender at times 1 and 2.

Time	Variables	1	2	3	4	5	6
Time 1	Self-concept of computer ability (1)	-					
	Self-concept of math ability (2)	-.03	-		-.02	-.06	-.15*
	Math performance (3)	-.14**	.69**	-	-.13	.74**	.67**
Time 2	Self-concept of computer ability (4)	-					
	Self-concept of math ability (5)	.01	-		-.07	-.06	-.30**
	Math performance (6)	-.22**	.68**	-	-.13	.71**	.69**

The upper right side of the second section of the table refers to girls in bold.

\* Correlation is significant at 0.05 (bilateral).  
 \*\* Correlation is significant at 0.01 (bilateral).

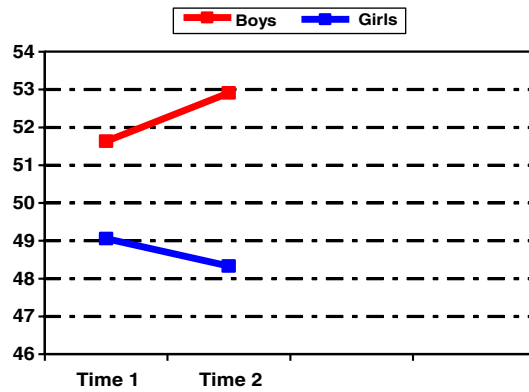


Fig. 1. Gender x time interaction on self-concept of computer ability.

computer ability than girls ( $M = 47.54$ ). The gender x track of *Bachillerato* interaction effect was statistically significant [ $F(2,406) = 4.241, p < .05; \eta^2 = .02$ ]. Neither the main effect of time [ $F(1,406) = .334, p > .05$ ] nor the interaction of time x modality of *Bachillerato* [ $F(2,406) = .104, p > .05$ ] or time x gender x subject area [ $F(2,406) = 1.351, p > .05$ ] resulted statistically significant. Young men in the Arts *Bachillerato* ( $M = 55.75$ ) reported higher self-concept of computer ability than young men in the Science and Technology ( $M = 52.88$ ) and in the Humanities and Social Sciences ( $M = 50.54$ ) *Bachilleratos*. Likewise, young women in the Humanities and Social Sciences *Bachillerato* ( $M = 49.98$ ) reported a higher self-concept of computer ability than young women in the Science and Technology ( $M = 47.36$ ) and Arts ( $M = 45.29$ ) *Bachilleratos*. The differences across subject areas were higher among young men than among young women.

With regard to self-concept of math ability, the 2 (gender) x 2 (time) x 3 (track of *Bachillerato*) repeated measures ANOVA rendered a significant effect of time [ $F(2,413) = .648, p < .010; \eta^2 = .02$ ] and of the track of *Bachillerato* [ $F(2,413) = .43018, p < .001; \eta^2 = .17$ ]. Consequently, participants had a higher self-concept of math ability at time 1 ( $M = 47.61$ ) than at time 2 ( $M = 45.41$ ). Similarly, those participants in the Science and Technology *Bachillerato* ( $M = 54.40$ ) reported a higher self concept of math ability than those in the Humanities and Social Sciences ( $M = 47.20$ ) and Arts ( $M = 37.93$ ) *Bachilleratos*. However, the effect of gender did not yield any significant effect when taken alone [ $F(1,413) = 1.759, p > .05$ ].

The interactions of gender x track of *Bachillerato* [ $F(2,424) = 3.047, p < .05; \eta^2 = .01$ ] and of gender x time x subject area [ $F(2,413) = 4.074, p < .018; \eta^2 = .02$ ] on self-concept of math ability reached statistical significance. Therefore, the young men and women in the Science and Technology *Bachillerato* ( $M_{male} = 55.70; M_{female} = 53.09$ ) reported higher self-concept of math ability than young men and women in the Humanities and Social Sciences ( $M_{male} = 47.25; M_{female} = 47.14$ ) and Arts *Bachilleratos* ( $M_{male} = 32; M_{female} = 43.86$ ). The gender difference is more marked for those students enrolled in the Arts *Bachillerato*, with the young women reporting higher self-concept of math ability than the young men.

Across time, the young men and young women in the Science and Technology *Bachillerato* had higher self-concept of math ability at time 1 ( $M_{male} = 56.38; M_{female} = 54.96$ ) than at time 2 ( $M_{male} = 55.01; M_{female} = 51.23$ ). Similarly, young men and young women in the Humanities and Social Sciences ( $M_{male} = 48.34; M_{female} = 47.67$ ) and Arts *Bachilleratos* ( $M_{male} = 34; M_{female} = 44.29$ ) reported higher self-concept of math ability at time 1 than at time 2 ( $M_{male} = 46.16; M_{female} = 46.61$  and  $M_{male} = 30; M_{female} = 43.43$ ). As illustrated in Fig. 2, adolescents in the Arts *Bachillerato* (particularly young men) and young women in the Scientific and Technology *Bachillerato* reported a higher decline across time in the assessment of their math ability.

Finally and with regard to math performance, the 2 (gender) x 2 (time) x 3 (track of *Bachillerato*) repeated ANOVA measures yielded a main effect of time [ $F(1,409) = 17.609, p < .001; \eta^2 = .04$ ], of gender [ $F(1,409) = 8.991, p < .003; \eta^2 = .02$ ] and of the track

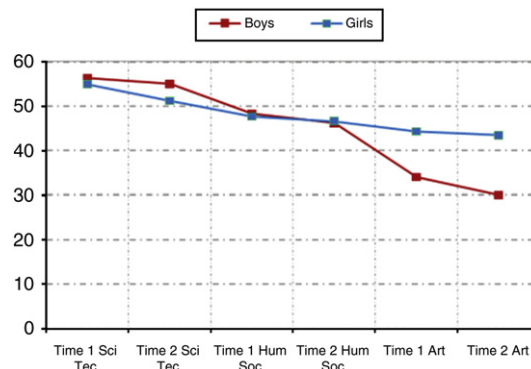


Fig. 2. Gender x track of *Bachillerato* x time interaction on self-concept of math ability.

**Table 3**

Cross tabulation of gender for ICT-related studies over time.

Time	Gender	Choice of ICT studies			Type of ICT studies		
		Yes ICT	No ICT	Total	Computer Science	Telecom. Engineering	Total
Time 1	Girls	123 (40%) Res: -2.7	322 (57%) Res: 2.0	425	82 (36%) Res: -1.0	33 (56%) Res: 1.9	115
	Boys	184 (60%) Res: 2.8	241 (43%) Res: -2.1	445	144 (64%) Res: .8	26 (44%) Res: -1.5	170
	Total	307 (35%)	563 (65%)	870	226	59	285
Time 2	Girls	36 (41%) Res: -2.0	200 (61%) Res: 1.0	236	22 (37)% Res: -.5	13 (50%) Res: .7	35
	Boys	52 (59%) Res: 2.3	36 (39%) Res: -1.2	180	37 (63%) Res: .4	13 (50%) Res (-.6)	50
	Total	88 (21%)	328 (79%)	416	59 (69%)	26 (21%)	85

of *Bachillerato* [ $F(1,409) = 44.300, p < .001; \eta^2 = .18$ ]. Participants reported higher math performance at time 1 ( $M = 50.77$ ) than at time 2 ( $M = 46.18$ ); young women ( $M = 51.79$ ) reported higher math performance than young men ( $M = 45.16$ ) and participants in the Science and Technology *Bachillerato* ( $M = 55.29$ ) reported a higher math performance than participants in the Humanities and Social Sciences ( $M = 47.85$ ) and Arts ( $M = 42.29$ ) *Bachilleratos*.

The gender  $\times$  track of *Bachillerato* interaction effect on math performance was statistically significant [ $F(1,409) = 3.734, p < .025; \eta^2 = .02$ ]. However, the interactions between gender  $\times$  time [ $F(1,409) = .635, p > .05$ ], gender  $\times$  modality of *Bachillerato* [ $F(2,409) = .573, p > .05$ ] and gender  $\times$  time  $\times$  track of *Bachillerato* [ $F(2,409) = 2.156, p > .05$ ] were not statistically significant. The young men in the Science and Technology *Bachillerato* ( $M = 55.05$ ) reported higher math performance than the young men in the Humanities and Social Sciences ( $M = 46.43$ ) and Artistic *Bachilleratos* ( $M = 34$ ). Simultaneously, the young women in the Science and Technology *Bachillerato* ( $M = 55.53$ ) reported higher math performance than young women in the Arts ( $M = 50.57$ ) and the Humanities and Social Sciences ( $M = 49.28$ ) *Bachilleratos*. Once again, the gender difference is more marked for those students enrolled in the Arts *Bachillerato*.

**3.4. Objective 3: the prediction of choice of ICT-related studies**

In order to analyze the existence of gender differences in the choice and type of ICT-related studies participants are more likely to pursue in the future,  $X^2$  tests on the cross tab were carried out at times 1 and 2.

At time 1 (see Table 3), the young men reported a higher intention than the young women to pursue ICT-related studies [ $X^2(1,870) = 23.327, p < .001$ ]. Furthermore, while the young men were not more likely than expected to intent to pursue computer science, the young women were more likely than expected to intent to pursue Telecommunications Engineering [ $X^2(1,285) = 7.505, p < .01$ ]. Somewhat similar results characterize the time 2 data: the young men were more likely to intent to pursue ICT-related studies than the young women ( $X^2(1,416) = 11.382, p < .001$ ). No gender differences were observed in the type of ICT studies they would like to pursue in the future ( $X^2(1,85) = 1.204, p > .05$ ). Furthermore, there were no gender differences in aspirations for either computer science or telecommunications engineering.

Simple logistic regression was used to analyze the predictive role played by math and computer self-concept of ability and of math performance in explaining both gender and individual differences in ICT-related studies at time 1 and time 2.

At time 1 (see Table 4) while self-concept of math ability did not predict the intention to pursue ICT-related studies [ $OR = .998, p > .05$ ], self-concept of computer ability predicted the intention to pursue ICT-related studies [ $OR = 1.084, p < .001$ ]. Math performance also did not predict the intention to pursue ICT-related studies [ $OR = .998; p > .05$ ]. Gender on the other

**Table 4**

Simple logistic regressions to predict the intention to pursue ICT-related studies.

Time	Variables	B	Wald	OR
Time 1	Gender	-.693	23.034	.500***
	Self-concept of computer ability	.080	81.121	1.084***
	Self-concept of math ability	.011	2.311	1.011
	Math-performance	-.002	.071	.998
Time 2	Gender	.814	11.077	2.257***
	Self-concept of computer ability	.077	25.753	1.080***
	Self-concept of math ability	.013	.972	1.013
	Math performance	.000	.002	1.000
Moderation	Math performance	.106	7.019	1.112**
	Gender	2.929	4.760	18.718*
	Gender $\times$ math performance	-.074	6.957	.928**

\*\*\*  $p < .001$ .

\*\*  $p < .01$ .

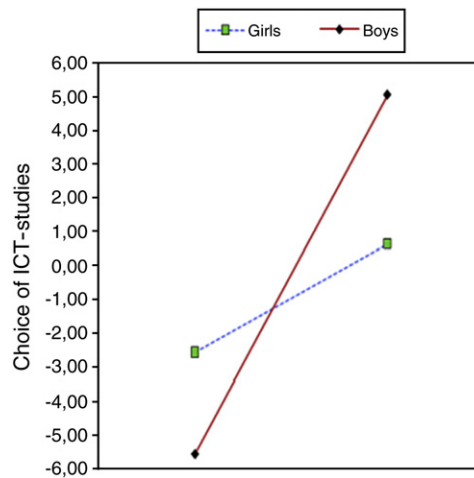


Fig. 3. Gender and math performance interaction effect on the pursuit of ICT studies at time 2.

hand did predict the desire to pursue ICT-related studies [OR = .443;  $p < .01$ ] with young men being more likely to report this aspiration than young women. The interaction between gender and the independent variables was not statistically significant.

At time 2 the self-concept of computer ability predicted the intention to pursue ICT-related studies (OR = 1.080,  $p < .001$ ); participants with a higher self-concept of computer ability were more likely to intend to enroll in ICT-related studies. Nonetheless and congruent with the findings observed at time 1, neither self-concept of math ability [OR = 1.013,  $p > .05$ ] nor math performance [OR = 1.000;  $p > .05$ ] predicted the intention to pursue ICT-related studies. Gender predicted these students' desire to pursue ICT-related studies [OR = 2.257;  $p < .001$ ], with males being more likely to report such an aspiration. The gender  $\times$  math performance interaction was the only significant interaction in the prediction of the intention to pursue ICT-related studies. Young men's aspirations were more highly related to their reports of their math performance than were young women's. As a consequence, young men with high math performance were much more likely than comparably able young women to aspire to a career in ICT (see Fig. 3).

As self-concept of computer ability was the only psychological variable that predicted the intention to pursue ICT-related studies in this sample, mediation analyses were carried out to test the possible mediation effect of self-concept of computer ability in the relationship between gender and the intention to pursue ICT-related studies. Correlation analyses showed that self-concept of computer ability (the mediation variable) correlated significantly with gender (the independent variable) at time 1 ( $r = -.13^{**}$ ) and at time 2 ( $r = -.23^{**}$ ). Similarly self-concept of computer ability correlated significantly with the intention to pursue ICT-related studies (the dependent variable) at time 1 ( $r = .32^{**}$ ) and at time 2 ( $r = .26^{**}$ ). The intention to pursue ICT related studies also correlated significantly with gender at time 1 ( $r = -.14^{**}$ ) and at time 2 ( $r = -.17^{**}$ ).

At time 1, the independent variable (gender) predicted self-concept of computer ability ( $B = -.13$ ;  $p < .01$ ). The mediation variable (self-concept of computer ability) predicted the choice of ICT studies (Wald = 37.984,  $p < .001$ ). Gender predicted the choice of ICT-related studies (Wald = 8.457,  $p < .01$ ), but this effect is slightly reduced when the mediator variable was included in the model (Wald = 4.760,  $p < .05$ ).

At time 2, the independent variable (gender) predicted self-concept of computer ability ( $B = -.23$ ;  $p < .001$ ). The mediation variable (self-concept of computer ability) predicted the choice of ICT studies (Wald = 25.753,  $p < .001$ ). Gender predicted the choice of ICT-related studies (Wald = 8.508,  $p < .01$ ), but this effect lost significance when the variable self-concept of computer ability was included in the logistic regression model (Wald = 2.704,  $p > .05$ ). The Sobel test confirms that the mediation effect is significant at time 1 [ $Z = -2.432315$ ,  $p < .05$ ] and time 2 [ $Z = -3.499$ ,  $p < .001$ ].

Finally, an across time mediation analysis was carried out to provide an even more conservative test of the mediation effect. In this analysis we used self-concept of computer ability at time 1 as mediator and the choice of ICT at time 2 as dependent variable. Self-concept of computer ability at time 1 was found to correlate significantly with the choice of ICT-related studies at time 2 ( $r = .21^{**}$ ). As expected, gender predicted the choice of ICT-related studies at time 2 (Wald = 11.763,  $p < .001$ ), but the inclusion of self-concept of computer ability at time 1 in the second step reduced significantly the effect of gender (Wald = 8.402,  $p < .01$ ). Sobel test [ $Z = -2.33903$ ,  $p < .01$ ] confirmed the mediation effect of self-concept of computer ability at time 1 in the relationship between gender and the choice of ICT studies at time 2.

## 4. Discussion

### 4.1. Patterns of association among the constructs

We found a strong positive correlation between students' ratings of their math performance and their math ability self-concepts but not between their math performance and their computer ability self-concepts. This pattern of correlations can be

understood using the internal/external frame of reference as well as the Eccles Expectancy-Value Model of Achievement Related Choice (Eccles-Parsons et al., 1983; Marsh, 1986). Math performance and self-concept of math ability are highly correlated because achievement levels as indicated by grades are a primary source of information for the development of self-concepts. Furthermore, as in other studies, the association of performance indicators like grades or marks with ability self-concepts was stronger for males than for females perhaps due to the fact that males and the parents of males are more likely to attribute males' math success to ability rather than effort (Eccles et al., 1984; Marsh, 1986; Yee & Eccles, 1988).

Marsh's internal/external model also provides an explanation for why self-concept of math ability and self-concept of computer ability were not correlated. Students may see themselves as either 'math persons' or 'computer persons' but not both at the same time (Marsh & Hau, 2004). The fact that young women's self-concept of computer ability is significantly and negatively correlated with math performance can also be explained by Marsh's internal/external frame of reference. If students do internal comparisons across domains as they form their ability self-concepts, then doing very well in one subject area could lead them to conclude that they are not so talented in another subject area. Consequently, girls who have high grades in math may develop low computer ability self-concepts.

The fact that this negative association between math performance and self-concept of computer skills is only significant for the young women may also reflect a gender difference in the meaning associated with computer skills. If the young women are thinking about computer skills in terms of word processing and other more clerical tasks, then the strongly negative association could reflect the fact that they are not seeing a strong connection between computer skills and math skills. The fact that young women with the highest estimates of their computer skills at time 2 were in the Humanities/Social Science *Bachillerato* is consistent with this interpretation.

#### 4.2. Developmental changes and gender differences in ability self-concepts

In general, the participants reported a better performance in math and a higher self-concept of math ability at time 1 than at time 2. This decrease in self-concept of math ability and of math performance over time is in line with other authors' findings (Eccles, 1987; Fredricks & Eccles, 2002; Jacobs et al., 2002). As self-concept of math ability is positively correlated with math performance, it is congruent that self-concept of math ability decreases when math performance decreases. However, the gender  $\times$  time interaction was not significant for either self-concept of math ability and math performance, despite the fact that the females reported better performance than the males at time 1 and equally good performance at time 2. Why did the females not report higher math ability self-concepts than the males at both time points if math self-concepts are directly tied to performance?

Perhaps because males and females have slight different causal attribution patterns: males and their parents are more likely to attribute their math successes to their talent than are the female students and their parents. In contrast, females and their parents give more weight to effort than to ability in explaining the math successes of their own and their daughters (Eccles et al., 1984; Yee & Eccles, 1988). Over time such an attributional pattern can lead to the gender difference in math ability self-concepts (Wigfield & Eccles, 2002). This finding is also consistent with data showing that boys are more likely than girls to brag about their competence in math (Guimond & Roussel, 2001), even when their performance is equal or even lower than their female counterparts. It is also worth considering that gender differences in self-concept of math ability occur even among male and female students who have chosen to enter the Science/Technology *Bachillerato*.

As regards self-concept of computer ability, the young men also reported higher self-concept of computer ability than the young women at both times 1 and 2. Furthermore, while self-concept of computer ability increases in for male students over time, the female students experience a decrease in their self-concept of computer ability across time. The finding is in line with previous research demonstrating a gender gap in the perception of one's ability across time (Eccles, 1984; Fredricks & Eccles, 2002; Jacobs et al., 2002). This finding could be explained by group membership (boys need to perceive that they are better than girls in masculine domains), as other research has demonstrated using implicit and explicit measures of attitudes (Nosek, Banaji, & Greenwald, 2002). The stereotype that men are better than women in computer-related activities creates a pool of group comparison (men as an in-group and women as an out-group) that when made salient women evaluate their own competence in accordance with their membership to the group of women and the expectations held about them in those fields.

This gender gap seems to be higher at time 2 at time 1. Boys may reaffirm themselves considering their computer abilities higher (even higher than they really are) than girls because computer science is a male dominated field and when this aspect is made salient they must consider themselves more competent in this domain. Finally, however, it should be noted that the effect size of gender differences in self-concept of computer and math abilities (together with the effect size of gender and time interaction on self-concept of computer ability) is not high in most of the cases. Similarly, the effect sizes of time with self-concept of math ability and math performance are also low. However, the effect sizes in this study are comparable to the effect sizes for similar associations in most other studies of gender differences and developmental change.

#### 4.3. Difference across the three *Bachillerato* programs

Students in the Science and Technology *Bachillerato* feel more competent in math and also report better grades in math than the students enrolled in other two types of *Bachillerato*. Those students who are enrolled in the Science and Technology *Bachillerato* may be under a process of social comparison and group membership and for these reasons they need to *show-off* that they are better at math because their performance in math is supposed to be higher and thereby they have chosen a domain of *Bachillerato* that is

supposed to be math-related. In the Science and Technology *Bachillerato*, excelling at math is a salient factor and, for this reason, those students enrolled in technology-related *Bachillerato* perceive themselves as being more competent in this field.

Alternatively, those students who have chosen the Humanities and Social Science *Bachillerato* may perceive themselves less good at math-related studies because their performance in math has been lower, which, in turn, may have led them not to choose the domain of Science and Technology in *Bachillerato*. This salient effect of excelling in math in the Science and Technology *Bachillerato* may also push young women enrolled in this subject area to report a lower perception of their math competence across time, despite the fact that they also report higher math performance than their male counterparts at the two time points.

Consistent with our predictions, the type of *Bachillerato* chosen moderates the gender differences in all the variables considered in this study. Male and female students enrolled in the Science and Technology *Bachillerato* reported a higher self-perception of their math ability and also a higher math performance than the rest of students enrolled in the other *Bachilleratos*. In contrast, female students enrolled in the Humanities and Social Science *Bachillerato* and male students enrolled in the Artistic *Bachillerato* reported higher computer ability self-concept than their peers enrolled in the Science and Technology *Bachillerato*. These findings partially support previous results where it was observed that students who evaluate themselves competent in mathematics do not perceive that they are competent in computer science. It seems obvious that many students do not perceive an association between mathematics and computer science. It seems likely that these students are seeing computers as a tool in their areas of interest rather than a topic area to be studied in its own right – that is as a science. The effect size of the subject area is stronger when taken alone than when interacting with gender or time, especially for self-concept of math ability and math performance.

#### 4.4. Gender and ICT-related aspirations

Some of our findings are in line with other studies carried out in the USA in which the authors have concluded that women are less likely than males to pursue ICT related studies (Creamer et al., 2006; Zarrett et al., 2006; Zarrett & Malanchuk, 2005). Furthermore, at time 1 the females in this study preferred the studies of Telecommunications Engineering to the studies of computer science. This finding could be associated with the stereotypical image of computer science, which deters women from enrolling in this field. Alternatively, these findings could be also related to the association of ICTs to a male-dominated area and the stereotypes about the lack of social abilities mostly associated with computer scientists and their geeky and nerdy characteristics, stereotypes incongruent with women's gender stereotypes (Margolis & Fisher, 2002).

The fact that these young women prefer Telecommunications Engineering could also be related to the lack of knowledge about what Telecommunications Engineering entails because this profession is frequently associated with other professions, such as Journalism or Audiovisuals. In contrast, these young men are not more likely than expected to choose computer science than telecommunications engineering. At time 2, both the young men and women show no differences in the type of ICT study they would like to pursue maybe because they know much more about what they will do in the future than a year earlier.

On the one hand, we also found that self-concept of computer ability predicts the intention to pursue ICT-related studies at both times 1 and 2 while neither self-concept of math ability nor math performance does. Similarly, at time 2 gender moderates the association of math performance with the students' the intention to pursue of ICT-related studies, with the association being much stronger for male than for female students. This pattern of result suggests that students, males in particular, have come to think that their math abilities are particularly important for success in the ICT field. Having high math ability is also relevant to pursuing other science related degrees, such as medicine, chemistry, biology, physical science and other technological studies, as well as the humanities and social sciences.

Given this close connection between computer ability self concepts and aspirations to enter ICT fields, coupled with the gender differences in both of the variables, it is not surprising that self-concept of computer ability mediates the association of gender with the choice of ICT-related studies (Sáinz, 2007). This finding confirms our prediction that gender differences in the choice of ICT studies can be explained by the influence of self-concept of computer ability at time 1, time 2 and across time.

#### 4.5. More general conclusions

This is one of the first studies focused on the ontogeny of gender differences in self-concept of computer and math abilities over two consecutive academic years in the context of Spain. It is also the first study that looks simultaneously at the role of ability self-concepts in both math and computer science in shaping adolescents' interest in pursuing ICT-related studies. Finally it is the first study in Spain that focused gender differences in the ability self-concept for both computers and math as mediators of the gender differences in secondary school students' intention to pursue ICT-related studies. In general, our results demonstrate the importance of looking more specifically at role students' computer ability self-concepts, rather than their math ability self-concepts if one wants to understand both individual and gender differences in the pursuit of careers in ICT. Our findings also suggest that there is a need for an even more differentiated view of what types of computer skills students are thinking about when they rate their computer abilities.

Secondly, this paper is directly relevant to our understanding of gender differences in the transition from compulsory secondary education into higher secondary education, with a special emphasis on students' selection of the different modalities of *Bachillerato*. Young men and women differ in their likelihood of aspiring to ICT professions already at the end of compulsory secondary education. There is also a substantial difference in the likelihood of the male students entering the Humanities and Social Science *Bachillerato* than the female students, leading to substantial gender difference in this *Bachillerato* alone. Although the females were slightly less likely than the males to enter the Science and Technology *Bachillerato*, this difference was quite small in

comparison the gender imbalance in the Humanities and Social Science *Bachillerato*. It seems likely that disparity reflects the fact that many more females with a high math self-concept and a high computer self-concept are choosing to enter the Humanities and Social Science *Bachillerato* than their male peers, as evidenced by our mediational analyses. Why is this so? It could be that males with high math and high computer abilities are being strongly encouraged to enter ICT fields; alternatively it could be that many females with high math and computer abilities do not want to go into ICT fields because of the stereotypes they hold about these fields. Future research is needed to answer this question. But independent of the answer, one needs to think about the impact of these early career decisions on the future options open to both young men and women in Spain.

Future research carried out in Spain should incorporate aspects related to self-concept of ability in other domains (such as reading, languages or biology) where women normally consider themselves more competent than their male counterparts (Eccles, 1987; Skaalvik & Skaalvik, 2004). It is important to compare girls' self-concept of ability in those feminine domains to their self-concept of ability in other male dominated domains (such as physical science or computer science) or neutral domains (such as math domain) across time and their role in the prediction of ICT versus other studies.

Since there is a dearth of longitudinal studies in the Spanish scientific literature, more longitudinal research should be carried out covering larger cohorts of ages, from early years of the formal educational system to university studies in order to analyze how the transitions to different educational levels that occur influence the ontogeny of ability self-concepts and interests as well as to understand better how decisions about course enrollment take place during the different stages of secondary education and pre-university years.

Despite the fact that this study focuses on a short developmental time frame, it grows out of the first attempt to analyze the transition between compulsory secondary education and upper secondary education in the Spanish context and the influence of the tracking system in *Bachillerato* on students' future career plans. This transition period plays a major role in the way females and males perceive their own abilities and select educational trajectories in accordance to those perceptions.

#### 4.6. Limitations and policy implications

A major limitation of this study is the high rate of drop-out of students from time 1 to time 2. In this regard, follow-up strategies should be improved in order to contact students outside the academic setting, preserving for this purpose their anonymity and confidentiality of all the gathered data. The self-reported nature of math performance is an additional drawback of the current research. Future research should find the way to contrast the real performance with the self-reported performance of students in mathematics, guaranteeing for this purpose confidentiality and anonymity of the data collected along with strategies to follow-up their real performance in different domains (for instance, using teachers' reports).

In line with other authors' conclusions, efforts to encourage mathematics and computer science excellence in girls may have no impact on girls' perceptions of competence in those domains, leaving them vulnerable to the implicit threat of stereotypes (Kurtz-Costes et al., 2008). The current educational system may reinforce the persistence of gender differences in achievement in different domains. Therefore, it is necessary that the family and school contexts collaborate together in order to allow both girls and boys to feel competent about their abilities to master many different domains. At a practical level, the aforementioned findings suggest that intervention measures should target young women's perception of math ability and reduce the likelihood that women with good math qualifications do not consider careers with a high math component.

On the other hand, it is necessary to analyze to what extent in subjects where computing is taught and used as a complementary teaching tool, girls and boys are equally motivated to use computers and other technologies in the classroom. Despite the fact that policy makers have placed a high priority on issues of gender equality, with particular attention being paid to the disadvantages faced by females, more efforts are needed if we want to increase the number of women in the development of ICT-related technologies, knowledge and practice. The shortage of women in this field is inconsistent with the goal of creating an information-based society in which women are fully integrated in the design–production–use system, necessary to take part in equal terms of the advantages of the information society.

#### Acknowledgments

This paper is part of a broader research project financed by the Catalan Women Institute ASC/46/2008 and was written during a research visit financed by José Castillejo's Postdoctoral Grant Program. The authors would like to thank Beatriz López, Julio Meneses, Esther Fatsini, Pilar Prat and Jordi Solé for their collaboration in the collection of data and preparation of data analysis.

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Please cite this article as: Sáinz, M., & Eccles, J., Self-concept of computer and math ability: Gender implications across time and within ICT studies, *Journal of Vocational Behavior* (2011), doi:10.1016/j.jvb.2011.08.005

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