Interest in Scientific and Technological Careers in Peruvian School Students

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Abstract. The present study analyzed Peruvian students' expectations to get involved in scientific and technological careers and factors associated with those expectations through the analysis of PISA 2015 data. The expectancy-value theory was taken as framework to analyze science career expectations since it considers individuals' motivation, self-beliefs and attitudes, variables that have been proved to be influential in career choice. Analytical procedures included confirmatory factor analysis and binary logistic regression. Findings confirmed the importance of gender roles, socioeconomic status and scientific capital in the formation of interest in scientific or technological careers as well as attitudinal and motivational factors, as argued by the expectation-value theory.

Keywords: Science, technology, career, expectancy-value theory

1 Introduction

Scientific knowledge provides the most comprehensive and reliable explanations about the material world [29]. Also, many of the most important global challenges today (e.g., global warming) require scientific knowledge for proper conceptualization and the search for effective solutions [17]. Therefore, it is crucial for countries to have citizens who, from an early age, develop interest and willingness for choosing careers related to science and technology. However, numerous evidences suggest a growing lack of interest in school science among students [6], [17], [27]. In Peru, according to the II National University Census 2010, of the total undergraduate students enrolled that year, 23% studied basic sciences, engineering and technology; while, in graduate school, this proportion decreased to 6% [10]. This panorama

shows limitations in the availability of professionals involved in science, technology and innovation.

PISA 2015 addressed this concern and raised, as part of its conceptual evaluation framework, that science interest is also part of scientific competence, in the same way as scientific skills, knowledge and beliefs supporting scientific work are [24]. Specifically, PISA 2015 examined the interest showed by 15-year-old students towards scientific and technological careers. The present study used PISA 2015 data to analyze Peruvian students' expectations to get involved in scientific and technological careers and to identify factors related to those expectations.

1.1 Factors Influencing Scientific and Technological Careers Choice

Career choice is based on sociocultural issues related to the construction of identity, especially in late modern societies [7]. In these contexts, individuals have greater freedom in its construction and can articulate in that process interests, goals and personal values [15]. The importance of family and socioeconomic background has been emphasized [8]. Thus, Aschbacher, Li and Roth [3] found that science high-achieving students used to come from high income families. Similarly, Archer, DeWitt and Willis [2] argued that the probability that a child expresses and maintains his interest in science will be strongly associated with his family scientific capital (e.g., having parents graduated or working in science matters). Another relevant aspect is age; evidence suggests that science interest arising from a very early stage might influence science vocational choices [27].

Another relevant factor for scientific careers choice involves gender roles. Thus, women are usually more interested in medical, biological and health sciences [30] than in mathematics, engineering and computer science, careers that draw more attention among males [13]. These differences might be explained by the influence of cultural beliefs and patterns related to gender on students' career expectations [17]. For example, there is evidence that women are more willing to make professional sacrifices than men, to assure their family's wellbeing [12]. In addition, they perceive that scientific careers will not allow them to harmonize between their work and personal life [16]. Similarly, women, unlike men, often prefer careers that allow them to interact and develop altruistic and reciprocal relationships with others [12]. Overall, these findings suggest that choosing certain careers might be influenced by cultural values associated with them, as well as gender-related role expectations.

Regarding school variables, the quality of teaching has shown a significant influence on participation and good performance in science courses [32]. Thus, a study carried out in USA with university students found that one of the most relevant predictors of good performance in these courses was high school education [31]. In contrast, transition from primary to secondary school, low levels of experimental work in class, as well as the lack of references from the scientific field might cause adverse dispositions towards science in school [5].

The expectation-value theory states that individual differences in decision making, involvement and persistence in certain activities can be explained based on attitudes related to how well one can perform in these activities and the assessment attributed to that task [34]. Attitudes can be defined as individuals' feelings and appraisals towards certain objects [27], to that extent, they

precede and guide behavior in various life domains. Attitudes have cognitive, affective and behavioral components, and vary according to their content (e.g. attitudes toward science), direction (positive, negative or neutral) and intensity (e.g. agree/disagree). Regarding attitudes towards science, they are defined as students' affections, beliefs and values towards school science, specific scientific topics and science implications for society and daily life [32]. Among these attitudes, achievement-related emotions can have a positive (such as science enjoyment) or negative effect (such as science anxiety) on behavior [29].

Motivational orientations, which are closely related to emotions, can be divided into intrinsic and instrumental. Thus, it has been found that students with high levels of interest (intrinsic motivation) are able to acquire new knowledge, persevere and meet goals, get involved in scientific activities, etc. [20]. In addition, empirical research is consistent in pointing out that science interest is crucial for scientific careers choice especially when it is acquired in early stages of schooling [22]. Instead, instrumental motivation is related to the expected outcomes and consequences of behaviors, rather than the joyful of learning itself, and to students' beliefs that science learning will be useful in the future [29]. Another relevant aspect has to do with self-efficacy, which reflects subjective beliefs about one's ability for performing optimally in specific science tasks, and is based on previous mastery experiences, vicarious experiences, social persuasion and physiological activation [4], [14], [18], [21], [29].

The present study examined the role of background, expectations, motivation, self-beliefs and attitudes in the development of interest in choosing scientific and technological careers in Peruvian students. Specifically, the study poses the following research questions: What are the students' scientific and technological career expectations? Which factors are associated with students' science and technological-related career expectations? Are there interactions in the relationship between expectation-value variables and scientific career choice according to student characteristics, specifically according to sex and SES?

2 Method

2.1 Sample

The Peruvian sample evaluated in PISA 2015 consisted of 6971 students (50.2% male, 49.7% female) from 281 educational institutions, aged between 15 and 16 (M = 15.66, $S.D.$ = 0.47), selected through a probabilistic, stratified, two-stage cluster sampling [25]. Ninety-three percent of the participants had Spanish as their primary language, while 6% and 1% had an indigenous language and a foreign language, respectively. Seventy-six percent attended upper secondary education (timely enrollment), while 24% attended secondary education (school backwardness).

2.2 Variables

Except for SES, the variables used in this study come from the PISA 2015 student questionnaire [28]. The student socioeconomic status (SES) index was constructed by the Office of Learning Quality Measurement of the Ministry of Education of Peru and has proven to be a valid and reliable measure in Peruvian educational contexts [23].

2.3 Analytical strategy

Binary logistic regression models were estimated in order to explore the relationship between different variables and the probability that students were interested in ST careers. These variables were introduced in blocks and sequentially in nested models. In addition, the presence of moderation effects (according to gender and SES) was also tested. In the case of SES, this variable was converted to a categorical one to classify students according to their SES level: high, medium, low and very low [23]. The fit of the final model was assessed through the Bayesian Information Criterion (BIC) as well as for its capacity to classify the observed data. All statistical and graphical analysis were carried out using the R 3.6.1 language [26] and the following packages: 'intsvy' [9], 'glmm' [19] and 'ggplot2' [33].

3 Results

3.1 Descriptive analysis

Table 2 shows the percentages of students who aspire to a ST career according to the characteristics of the students. As mentioned, 39.5% of the students reported having the expectation of performing in a scientific or technological career at 30 years old while 60.5% did not report such interest. In general, the engineering career was the one that generated the most interest (21.9%), followed by health careers (13.4%).

Table 2. Distribution of interest in scientific and technological careers by stratum.

		Science & Engineering (%)	Health Professionals (%)	Science a technolog careers Communication Technology Professionals (%)	Scientific Technicians (%)	Other careers (%)
National		21.9	13.4	3.8	0.5	60.5
Gender	Male	29.4	6.9	6.5	0.8	56.4
	Female	14.2	19.9	1.0	0.2	64.7
SES level	Very low	17.7	12.5	1.6	0.4	67.8
	Low	22.2 24.6	11.9 14.7	3.7 6.4	0.8 0.5	61.4
	Medium					53.8
	High	27.9	15.6	4.5	0.2	51.8
Science Performance (PISA 2015)	Below level 2	18.0	12.9	2.4	0.6	66.1
	Level 2	25.9 30.5	13.6 14.3	5.0 6.7	0.3	55.1
	Level 3	26.2	18.0	8.8	0.4	48.0
	Above level 3				0.00	47.1

Source: OECD. PISA 2015 data. Own elaboration.

Students who showed a greater willingness to opt for engineering careers were male students, as well as those with higher socioeconomic status and higher performance in the PISA science test. On the contrary, women were more interested in health careers.

3.2 Binary logistic regression models

Table 3 reports the results of the binary logistic regression models. In model 1, women were associated with decreased odds of interest in ST careers ($b = 0.664$, $p < .05$), compared to men. Also, having an indigenous ($b = 0.852$, $p < .05$) or foreign native language ($b = 0.771$, $p < .05$) were associated with decreased odds of interest in these careers, compared to Spanish native language. On the contrary, greater student ($b = 1.174$, $p < .05$) and school SES ($b = 1.051$, $p < .05$), as well as having timely enrollment ($b = 1.363$, $p < .05$), were associated with increased odds of choosing a ST career. On the other hand, having at least one parent dedicated to a scientific or technological occupation was related with greater odds of interest in these types of occupations ($b = 1.733$, $p < .05$).

In model 2 after controlling for the base model variables effects, instrumental motivation ($b = 1.377$, $p < .05$), achievement motivation ($b = 1.209$, $p < .05$), involvement in scientific activities ($b = 1.139$, $p < .05$) and interest in science ($b = 1.271$, $p < .05$) were all positively associated with increased odds of interest in a ST career. On the other hand, no significant results were found for test anxiety, science self-efficacy, enjoyment of science and emotional support of parents. Additionally, in model 3 a greater frequency in the use of pedagogical strategies based on inquiry was associated with decreased odds of showing interest in careers of this type ($b = 0.878$, $p < .05$).

Interaction effects were modeled in order to verify if relationships found differed according to strata (models 4, 5, 6 and 7). Thus, it was found that the relationship between anxiety and scientific aspirations depended on the student's gender (model 6). In this way, at higher anxiety scores, women had a greater chance of being interested in ST careers than men ($b = 1.336$, $p < .05$). It was also found that the association between instrumental motivation and occupational interest in science varied according to the student SES level (model 7). Therefore, as instrumental motivation scores increased, students with a higher SES had a greater chance of aspiring to pursue a career in science or technology ($b = 1.139$, $p < .05$). Finally, although at first there was no significant interaction effect between socioeconomic status and inquiry-based science teaching (model 5), this effect became significant in the final model (model 8). All significant interactions included in the final model appear graphically in Figure 1.

The final model (8) integrates information from previous models. Here, most of the trends observed in partial models remained, except for those described below. Native language (indigenous and foreign), school SES and inquiry-based science teaching ceased to be significant after controlling for the rest of the variable's effects included in the final model. On the other hand, the effect of interaction between inquiry and SES (model 5) became significant in the final model. This effect, however, was not consistent with its graphic representation in Figure 1 and may not be reliable (therefore, it will not be discussed in the final section of the article). Finally, the final model showed a better fit to the data (BIC = 6235.7) than a null model without predictive variables (BIC = 9305.4). In addition, the final model adequately classified 63.4% of the data.

Table 3. Summary of models predicting science-related career aspirations (PISA 2015).

	Models[1]							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables		0.619*	0.619*	0.619*	0.613*	0.619*	0.619*	0.619*
Gender(Female)	0.664*							
Language(Indigenous)[2]	0.852*	1.116	1.185	1.197	1.185	1.197	1.139	1.150
Language(Foreign)[2]	0.771*	0.787	0.712	0.719	0.726	0.698	0.705	0.712
Student SES	1.174*	1.105*	1.116*	1.116*	1.116 *	1.116	1.105	1.105*
School SES	1.051*	1.185*	1.174	1.174	1.162	1.174	1.185*	1.162
Timely Enrollment	1.363*	1.363*	1.336*	1.336*	1.336*	1.336*	1.336*	1.323*
Science-related parent occupation	1.733*	1.716*	1.699*	1.699*	1.699*	1.716*	1.716*	1.733*
Instrumental motivation		1.377*	1.377*	1.377*	1.390*	1.391*	1.336*	1.336*
Test anxiety		0.914	0.896	0.896	0.887	0.771*	0.896	0.771
Achievement motivation		1.209*	1.234*	1.234*	1.234*	1.234*	1.234*	1.234*
Science self-efficacy		0.951	0.951	0.951	0.951	0.951	0.951	0.951
Science activities		1.139*	1.197*	1.197*	1.197*	1.197*	1.197*	1.197*
Enjoyment of science		1.041	1.073	1.073	1.073	1.073	1.062	1.062
Interest in science		1.271*	1.271*	1.271*	1.271*	1.271*	1.259*	1.259*
Parents support		1.030	1.020	1.020	1.020	1.020	1.030	1.030
Inquiry-based science teaching			0.878*	0.827*	0.896	0.878*	0.869*	0.835
Female x Inquiry				1.139				1.174
SES x Inquiry					0.905			0.878*
Female x Anxiety						1.336*		1.350*
SES x Inst. Motivation							1.139*	1.162*
Intercept/Constant	0.595*	0.613*	0.619*	0.619*	0.619*	0.619*	0.625*	0.625*
N(Students)	6603	5025	4737	4737	4737	4737	4737	4737

*$p < .05$. [1]For each model, the exponential coefficients (odds ratios) associated with the predictors are reported. For one unit change, an odds ratio above 1 reflects a greater probability that the student is interested in a ST career, while an odds ratio below 1 reflects a decrease in this probability. [2] Reference = Spanish language.

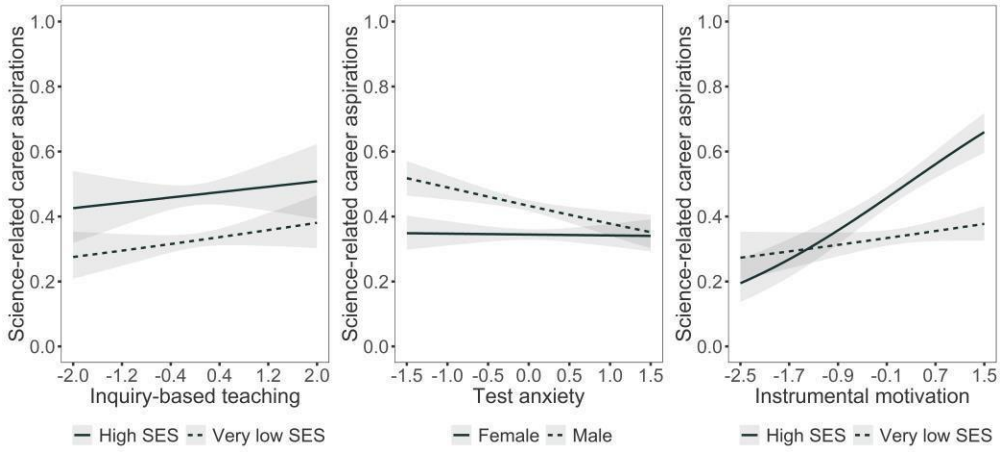

Figure 1. Moderation effects: Inquiry x SES, Anxiety x Sex, Instrumental Motivation x SES.

4 Discussion

The study aimed to (1) to explore the scientific and technological career expectations shown by Peruvian students; (2) to explore the factors associated to interest in this type of careers; and (3) to analyze the existence of moderation effects in the relationship between affective and motivational variables with the interest in science careers. In general, the results allowed to identify that approximately 40% of students expressed the intention of being involved in scientific careers at 30 years old, with engineering and health careers as the ones that concentrated greater interest. Evidence shows that career expectations are differentiated by gender which correspond to the international trend: women prefer health careers while men prefer engineering careers [30]. It is important to mention that gender differences in socialization often take place both in educational and family contexts. It is likely that parents and teachers are inclined to encourage and reinforce more intensely among male students the active exploration of environments and the manipulation of objects, which constitute essential features of scientific work. On the contrary, women might place a greater emphasis on activities related to interpersonal care (e.g., health careers). In sum, gender stereotypes might generate different routes in the development of vocational and occupational interests [12].

The results also showed the importance of students' background as well as motivational and attitudinal aspects. Among variables related to students´ background, there was found a positive relationship between science and technological careers expectations and student socioeconomic status, timely enrollment, and having at least one parent working in science. The latter would evidence the importance of the student's scientific capital in the construction of identity related to science and, as Archer, DeWitt and Willis [2] have suggested, would support arguments about the early influence of scientific capital on the expression and development of science interest. Thus, having parents involved in science-related jobs might

drive interest in scientific subjects and occupations, consumption of cultural products, participation in out- of- school science activities, interaction with people involved in science, as well as the development of favorable dispositions toward this field [1].

In addition, the present study found that domains highlighted by the expectancy-value theory showed to be important antecedents of interest in scientific and technological careers such as instrumental motivation, achievement motivation, engagement in scientific activities and interest in science topics. These results also coincide with previous evidence according to which the persistence and effort to excel in science courses, the spontaneous participation in science-related activities during free time, as well as the disposition for being informed on science topics show a positive influence on interest in scientific and technological careers [20]. Henceforth, it was found that, besides students` background, there are subjective dispositions favorable to science career expectations and that both factors might, very probably, interact among them configuring processes of identity construction in which science plays an important role. Regarding pedagogical practices, a negative association was found between interest in scientific careers and inquiry- based teaching, even this relationship turned into a non-significant one in the final model. Although these findings are counterintuitive since it would be expected that inquiry nurture interest in science, they are consistent with studies reporting that this teaching approach is negatively associated with science performance in standardized tests [11].

In relation to interaction effects, instrumental motivation was found to favor science career choice, especially in those students with a higher SES. These students are likely to have a more favorable environment (e.g., greater scientific capital) for the development of vocational paths that reflect their expectations and interests, whether instrumental (as verified in the present study) or intrinsic. Also, it was found that as anxiety increases in evaluation contexts, men are more likely to give up their interest in science and technology careers. This may suggest a greater women ability to persist in their goals, particularly in unfavorable conditions. It is also likely that, in the presence of difficulties, men will have greater freedom to give up interests or goals and opt for others.

In general terms, the results of this study emphasize the importance of gender roles, socioeconomic status and scientific capital in the formation of interest in studying a scientific or technological career. In addition, attitudinal and motivational factors showed their importance in science career expectation as postulated by the expectation-value theory [12]. As the main limitation of the study it is important to point out that, due to its cross-sectional design, it is not possible to make causal inferences or to generate conclusions about the process of development of interest in science and technology careers. Thereupon, the use of longitudinal designs is recommended to track fluctuations of science interest and other associated variables.

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