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Perfil y test vocacional para las carreras de Computadores, Agrícola y Enseñanza de la Matemática

Vocational profile and test for Computer, Agricultural and Mathematics Teaching majors

Alejandra Alfaro-Barquero
alealfaro@itcr.ac.cr
Instituto Tecnológico de Costa Rica
Costa Rica

Sonia Chinchilla-Brenes
schinchilla@itcr.ac.cr
Instituto Tecnológico de Costa Rica
Costa Rica

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Abstract: This research aimed at designing and validating a vocational preference test for three majors at Costa Rica Institute of Technology (ITCR): Computer Engineering, Agricultural Engineering, and Mathematics Teaching in Technological Environments. The sample of the study consisted of 13 educators (15.4% female, 84.6% male) and 435 students, 63.2% male and 36.8% female, with an average age of 20.74 years. A vocational profile by discipline was prepared, reviewed and validated by experts. The resulting document served as the basis for the vocational instrument. Subsequently, its psychometric properties were evaluated through factor analysis, obtaining adequate goodness-of-fit indicators. The test included a general skills and interests scale, as well as a career task scale. The existence of vocational profiles for each discipline was demonstrated and those participants who showed greater affinity with the profile of their major also showed greater vocational satisfaction. Significant differences were showed according to vocational satisfaction level in physical skills, leadership, mathematical reasoning, discipline self-regulation, visuospatial and chemistry ability.

Moreover, significant differences were found in favor of women in the means of biological ability, discipline self-regulation and visuospatial ability, in preference for tasks and interests in Mathematics Teaching and in Agricultural Engineering tasks. Men obtained higher averages in physical ability, mathematical ability and preference for tasks and interests in Computer Engineering.

Keywords: interests, ability, adult education, career choice, vocational guidance.

Resumen: La investigación buscó diseñar y evaluar una prueba de preferencias vocacionales para las carreras de Ingeniería en Computadores, Ingeniería Agrícola y Enseñanza de la Matemática con Entornos Tecnológicos, del Instituto Tecnológico de Costa Rica (ITCR). Participaron 13 docentes (15.4% mujeres, 84.6% hombres) y 435 estudiantes, con edad promedio de 20.74 años, 63.2% hombres y 36.8% mujeres. Se elaboró el perfil vocacional por disciplina y se revisó y validó con expertos. El documento resultante sirvió de base para elaborar el instrumento vocacional. Posteriormente, se evaluaron las propiedades psicométricas del mismo con análisis factoriales, obteniendo indicadores de bondad de ajuste adecuados. La prueba incluyó la escala de habilidades generales e intereses y tareas por carrera. Se evidenció la existencia de perfiles vocacionales para cada disciplina y quienes mostraron mayor afinidad con el perfil de su carrera evidenciaron mayor satisfacción vocacional. Específicamente, se encontraron diferencias significativas según satisfacción vocacional en los promedios de habilidad física, liderazgo, razonamiento matemático, autorregulación-disciplina, habilidad visoespacial y habilidad química.

Además, se encontraron diferencias significativas a favor de las mujeres en las medias de la habilidad biológica, autorregulación-disciplina, habilidad visoespacial y mayor preferencia por la enseñanza de la matemática y las tareas de ingeniería Agrícola. Los hombres obtuvieron mayores promedios en las habilidades física y matemática y mayor preferencia por las tareas e intereses de Ingeniería en Computación.

Palabras Clave: interés, habilidad, enseñanza superior, elección de profesión, orientación profesional.

1. Introduction

Vocational counseling is a process in which participants consider professional options, labor market conditions, and individual characteristics in order to make informed decisions when choosing the role at work (Bohoslavsky, 1984; Cepero, 2009). Some of the crucial variables that affect vocational choice include sex, interests, preferences, vocational security, school of origin, socioeconomic status, and social recognition (Álvarez et al., 2014; Carrasco et al., 2014; Cepero, 2009; Espíndola, 2015; Estrada, 2011; Hernández, 2001; Herrera & Burgoa, 2012; Sevilla et al., 2010). Other factors that affect the vocational choice are the lack of vocational guidance, little dissemination of and social resistance towards non-traditional careers, and admission tests (Barrera, 2016; Carrasco et al., 2014; Restrepo, Carvajal & Roldán 2016). In addition, incongruities have been found between the chosen major and interests of the students (Vargas & Huamán, 2019). At Costa Rica Institute of Technology (ITCR), it has been shown that 46% of those who drop out do so to the dissatisfaction with the major (Hernández-Jiménez et al., 2020).

In relation to sex, differences have also been found. While men show better performance in verbal and abstract reasoning, calculus, and physical abilities; and prefer areas such as mechanics, technology, electronics, construction, calculus and basic sciences, women excel in self-regulation-discipline, sociability, spelling, and language. In addition, women show a preference for the areas of communication, industrial, legal, humanistic, healthcare, health, and artistic design (Alfaro-Barquero & Chinchilla-Brenes, 2016, 2017, 2019, 2020; Echavarri et al., 2007; Fogliatto et al., 2003; Martínez & Ángeles 2016; Martínez-Martínez et al., 2016; Montero, 2005).

The foregoing shows that gender stereotypes affect women's expectations and reduce their labor participation in scientific-technological careers. In Costa Rica, the percentage of female unemployment increased from 15% in 2016 to 25% in 2021 (Adelfang, 2016; National Institute of Statistics and Censuses INEC, 2021; Donoso-Vázquez, 2012; Rosado, 2012). Besides, female employment in science and technology is of 33% (Rodríguez, 2016), and the enrollment of women at ITCR in 2021 corresponded to 37% of the total (X. Salas, personal communication, March 17, 2021). This is an echo of Latin American situation where "women face greater obstacles than men to access employment, and when they do, they are often excluded from decision-making positions" (United Nations UN, 2020, p.35). This also reveals the need for improving and increasing policies to attract women to engineering (Lent et al., 2004), in accordance with the sustainable development objectives of the United Nations regarding access to higher education (UN, 2015).

In addition, there is an inverse relationship between academic achievement and poverty, which highlights the lack of equity, access, and permanence in the educational system (State of the Nation, PEN, 2020). This is aggravated by the closures of educational centers due to the COVID-19 pandemic and the inequality access to technology and internet, which has possible repercussions on unemployment. Thus, for example, in Latin America and the Caribbean, young people face greater vulnerability, with unemployment rates of 17.9%, 11.77 percentage points more than adult unemployment (UN, 2020).

Regarding the vocational issue, this has been in the scope of scientific interest, but it does not have a solid theoretical framework. Thus, an empirical and exploratory approach predominates with little possibility of generalizing results and little clarity about future trends (Lobato, 2002). From vocational psychology, several approaches have been proposed to address this topic. For example, Counseling for Work and Relationship (CWR) emphasizes the meaning of life and its construction at work and during social interaction (Richardson, 2017). Alternatively, Systems Theory Framework (STF) of career development and counseling focuses on life history and narration of individual's experiences (Patton & McMahon, 2017). Another theory is Social Cognitive Career Theory (SCCT), which focuses on self-efficacy, outcome expectations, and goals. Perseverance, confidence in the achievement of academic results, and the probability of graduating are all influenced by outcome expectations, self-efficacy, interests, social support, and the value of goals (Dutta et al., 2015, Lent et al. al., 2004, Rodríguez et al., 2015, Schoenfeld 2017).

The theoretical bases of the present research, however, are provided by the Cognitive Information Processing Theory of career problem solving and decision making" or "Cognitive Information Processing Theory" (CIP) (Sampson, 2016), along with some general assumptions of the RIASEC theory (Holland, 1994) . CIP theory includes a pyramid of domains of information processing for decision-making, consisting of Knowledge, Decision-Making Skills and Executive Processing.

Knowledge Domain includes self-knowledge, interests, values, abilities, personality, spirituality, employment preferences and aspects of information about vocational options as study alternatives, information about the tasks of the professional field, knowledge, associated skills and employment options. Decision-Making Skills Domain involves the pattern of dependence, independence and interdependence, and the rational or emotional style in decision-making. The decision-making process (CASVE) includes five steps: communication, analysis, synthesis, evaluation and execution. Individuals become aware of where they are in the present and where they want to be in the future for an informed and conscious decision-making (communication), which improves their self-knowledge and favors the exploration of occupational and educational options (analysis), with a view to a vocational choice related to their personal characteristics (synthesis). Finally evaluate the costs and benefits for themselves and for other significant people (valuing), which enables the vocational choice and the plan to follow to achieve the goals (execution). Executive Processing Domain (or metacognition) contemplates the selection and use of strategies for solving problems and for self-regulating emotions.

As to Holland's RIASEC theory, it is integrated into CASVE analysis phase of CIP theory. The theory provides the person with a model to clarify relations between interests and occupations (McMahon & Watson, 2015). This is one of the most widely used theoretical approaches, together with Holland's Self-Directed Search (SDS) test (Reardon, 2017), whose factorial structure was confirmed by Dosil and Fernández (2001, in Cepero, 2009).

RIASEC includes 6 personality types: realistic, investigative, artistic, social, enterprising, and conventional. It proposes that vocational choice reflects personality, and that those who share a professional area tend to show similar behaviors, traits, and lifestyles (Urribarrí et al., 2013). Moreover, individuals search for working environments to put their skills, values and attitudes into practice (Fernández et al., 2019). Adjustment between vocational profile and personal traits shows in the degree of vocational satisfaction (Benítez, 2010) and in the commitment with professional training (Schelfhout, et al., 2019). Although similarities have been found between engineering students, such as the preference for scientific-technological research, creativity for problem solving, and mathematical ability (Alfaro-Barquero & Chinchilla-Brenes, 2016, 2017, 2019, 2020), Holland's theory is considered rather simplistic (Reardon, 2017), with broad typologies that do not allow an adequate differentiation of vocational preferences in scientific-technological careers (Alfaro-Barquero & Chinchilla-Brenes, 2016, 2017, 2019, 2020).

This study aims at continuing the research in Alfaro-Barquero & Chinchilla-Brenes (2016, 2017, 2019 and 2020) by developing the vocational profiles and scales of tasks and interests of the majors of Agricultural Engineering (AE), Computer Engineering (CE) and Teaching of Mathematics in Technological Environments (MT) to expand the instrument Tasks, interests and abilities in the area of engineering at ITCR. To this purpose, a mixed-approach research was followed, which combined qualitative strategies in the elaboration of the vocational profile of majors and quantitative techniques for construction and validation of task and interest scales of each major. In addition, skills and vocational satisfaction scales of Alfaro-Barquero & Chinchilla-Brenes (2016, 2017, 2019, 2020) were applied. Analysis of variance was also carried out according to major, vocational satisfaction, and sex.

It should be clarified that vocational profiles consider personality traits, interests, aptitudes or abilities (Díaz-Barajas et al., 2009), and that the population target consists of students in the process of choosing a major. In this study, profiles included a description of career, occupational tasks, interests, and abilities. Finally, this research proposes scales to evaluate the correspondence between vocational profiles of careers and preferences of individuals as inputs for knowledge analysis domain and domain skills for decision making, according to CIP theory.

2. Methods

This research was developed by implementing a mixed method, which incorporates "processes of collection, analysis and linking of quantitative and qualitative data in the same study" (Sampieri & Collado, 2014, p. 532). While qualitative strategies were implemented to build the vocational profiles, quantitative ones were used to design and validate the scales of tasks and interests of the psychometric instrument. Quantitative strategies were also used to evaluate psychometric qualities of the scale of abilities of the instrument, interests and abilities in the Engineering area at ITCR and vocational satisfaction scale (Alfaro-Barquero & Chinchilla-Brenes, 2016, 2017, 2019, 2020). Additionally, analysis of variance was carried out according to sex, career, and vocational satisfaction.

2.1. Participants

The target population included AE, CE and MT students, from second year of the degree onwards. The sample consisted of 435 students (56% of the total student population for the three majors) with a mean age of 20.74 years (SD = 3.99), 63.2% men and 36.8% women; 13 teachers (84.6% men and 15.4% women) were also included as part of the sample. Three subsamples were used.

1. **Construction of the vocational profile**: for the elaboration of the vocational profile, we worked with a sample of 71 students. Participants came from a class with the largest number of students registered and located in the last semester of each major according to their academic plan. Subsequently, the group of experts was selected: 18 students and 13 teachers. The student group was selected according to the following criteria: a) being an advanced student, b) showing a weighted average mark higher than the 75th percentile of the major, and c) expressing high vocational satisfaction. Via email, we explained the research objectives and invited 10 students per major to participate. We worked with those who indicated their willingness to collaborate. As for the educators, the director or coordinator of each career selected them according to the following criteria: a) qualification equal to or greater than 80 in the evaluation of teaching performance, b) at least two years of teaching experience, and c) preferable with a 2-year work experience in their field.

2. **Development of the vocational instrument and piloting**: the pilot version of the vocational instrument was written and applied to 73 freshman students. One group per area was randomly selected.

3. **Final application of the instrument**: the improved version of the instrument was applied to a sample of 273 students, with an error margin of 4% and a reliability of 95%. One or two courses of each year by major was included in the sample. Priority was given to courses with higher enrollment and instrument was applied to all students present in class when it was requested.

2.2. Instruments

Four measurement instruments were used as detailed below:

a) The Instrument for the collection of information on tasks, interests and abilities (Alfaro-Barquero and Chinchilla-Brenes, 2017). It is a questionnaire with open-ended questions applied on individual way. It looks for information about vocational profile (definition, professional areas of the career, skills, tasks and interests).

b) The vocational satisfaction assessment test (Alfaro-Barquero & Chinchilla-Brenes, 2020), which contains 8 items to measure the level of satisfaction with the major and the future professional role. It has a response scale that goes from 1 (lowest) to 5 (highest) degree of agreement. The scale reported a Cronbach's alpha reliability coefficient of .83. Vocational satisfaction refers to the degree of self-perceived personal well-being that an individual experiences when studying a major or working in a specific profession because of the affinity between the characteristics of the chosen profession and personal goals, interests, or abilities (Benítez, 2010).

c) The skills scale of the instrument Tasks, interests, and abilities in the engineering area at ITCR (Alfaro-Barquero & Chinchilla-Brenes, 2020), which assesses seven skills with Cronbach's alpha reliability values between .82 and .97. The abilities are conceptualized as skill degree of an individual in the solution and execution of mental or physical tasks, susceptible to evaluation through performance (Super & Crites, in Montero, 2005).

   This instrument assesses the following skills: mathematical reasoning (ability to understand, analyze and solve mathematical problems in the areas of arithmetic, algebra, functions and geometry); physics (ability to understand, analyze and apply processes, concepts and laws on physical phenomena); biological (ease of learning and understanding topics such as ecology, genetics, anatomy and taxonomy); chemistry (ability to understand the classification, behavior, processes, changes and chemical reactions of matter); visuospatial (ease of imagining, locating and ordering objects in the environment, design models and harmonize colors and designs); leadership (expertise for interpersonal relationships, project management and teamwork); and self-regulation-discipline (ability to carry out tasks with independence, proactivity, dedication, persistence and responsibility).

d) Finally, the new scales of tasks and vocational interests were developed and applied for the areas of AE, CE and MT. The interest items contain statements regarding the degree of inclination shown by an individual towards topics or activities related to each career. It is defined as the tendency of people to feel motivated by an area of reality with a greater predilection over other fields, including affective, behavioral, and cognitive manifestations towards the object of interest (Montero, 2005; Rodríguez, 2002).

On the other hand, the task scales include statements about the predilection of tasks performance that the future professional could carry out in their field. They refer to specific operations or activities that people carry out in a job or project in their daily professional practice (Super, in Rivas, 1998).

The task and interest scales have a numerical response option from 1 to 6, and showed Cronbach's alpha reliability values that ranged between .96 and .98. The AE, CE and MT scales were developed considering their subsequent inclusion in the instrument of Tasks, interests and skills in the engineering area at ITCR (Alfaro-Barquero & Chinchilla-Brenes, 2016, 2017, 2019 and 2020), which evaluates vocational preferences, defined as the expression of predilection for one or more professions, in accordance with personal characteristics and contextual determinants (Cepero, 2009).

2.3. Procedures

Data collection was carried out in the three stages detailed next.

1. **Construction of the vocational profile**. The instrument for collecting information on tasks, interests and skills according to career was applied (Alfaro-Barquero & Chinchilla-Brenes, 2017). The researchers integrated the information by area. It was reviewed, corrected, and validated with the group of expert students and teachers using the focus group technique. Sixteen work sessions were held, 10 with students and 8 with teachers, each lasting two and a half hours.

2. **Elaboration of the scales of tasks and interests AE, CE and MT and piloting**. After validating the vocational profiles, we proceeded to select of the contents and the writing of the items of the scales of tasks and interests according to major. Later, the Skills scale and the Vocational Satisfaction Assessment scale were revised and included. Finally, the information from the questionnaires was compiled into a database for the respective psychometric analysis, and improvements were made to the test for following application.

3. **Final application of the instrument**. Enhanced Task and Interest Scales for AE, CE and MT, Skills Scale, and Vocational Satisfaction Scale were implemented.

2.4. Data Analysis

In the first stage, the information obtained with the instrument for collecting information on tasks, interests and skills according to career (Alfaro-Barquero & Chinchilla-Brenes, 2017) was integrated into a text document by career, according to 1. definition, 2. academic areas of the curriculum, 3. occupational areas, 4. occupational tasks, 5. interests, and 6. skills.

Meetings by major were organized first with the group of students expert for the discussion, review, and elaboration of the vocational profile, based on the indicated categories of analysis. The information was projected with audiovisual equipment, researchers moderated the process. While the document was read, each member shared their perspective for the writing of the document based on categories of analysis, relevance, accessible vocabulary for non-expert population in the field, all in consensus with the teamwork. The same procedure was followed to improve and validate the text with the group of teaching experts.

Once the vocational profile was ready, interests and tasks representative of each career were selected for items elaboration. They were written as statements about the preference degree for tasks and interests and they were included in the instrument in random order.

After the scales of tasks and interests were written, and to carry out the pilot application, other assessment instruments were integrated: "the vocational satisfaction and skills scales" (Alfaro-Barquero & Chinchilla-Brenes 2016, 2017, 2019 and 2020). The information collected was processed in a database with descriptive statistics, factor analysis and the estimation of Cronbach's alpha reliability coefficients, with the aim of implementing improvements to the instrument and reviewing aspects of writing, prior to its final application.

In the final phase, the same instruments were applied to a sample of 273 students. The information obtained was entered into a database to perform the Confirmatory Factor Analysis to determine the convenience of the indicators used in the measurement of latent factors (Cea, 2002) for the items selection with the best psychometric qualities. The program EQS 6.1 was used for this, with the Maximum Likelihood estimation method, since "the maximum likelihood estimate is reasonably robust for many of the violations of the assumption of normality" (Cea, 2002, p. 521).

Subsequently, the proposed factorial structure for scales of tasks and interests was confirmed, each one with three factors: AE, CE and MT. The unidimensionality of the Vocational Satisfaction Assessment scale and the existence of the seven skill factors were also evaluated (Alfaro-Barquero & Chinchilla-Brenes, 2020).

For evaluating the proposed models, we considered the goodness-of-fit indicators RMSEA (the square root of the estimation error), CFI (comparative fit index) and the Chi square (x^2). A good fit is obtained when the CFI is equal to or greater than .9 and the RMSEA is less than or equal to .05, although a value less than .08 is considered acceptable (Cea, 2002) in social sciences. In the case of the Chi square, it is expected to be small and its probability greater than .05 (Cea, 2002). However, it is feasible to obtain values lower than this criterion when the normal distribution assumption is not fulfilled (Cea, 2002). Finally, the analysis of variance was carried out with SPSS to evaluate differences according to sex, vocational satisfaction, and career.

3. Results

As a result of the applied questionnaires, and of the review and validation process with experts, the vocational profiles of the three careers were developed. An extensive document was obtained that, for illustrative purposes, is presented as an executive summary in Table 1. The profiles favor the understanding of the knowledge that each discipline covers and describe some of the main occupational tasks, skills, and interests.

The quantitative stage results of the study are presented below, and the psychometric qualities of the instruments are described as well as the analyzes of variance. Confirmatory analyzes were carried out to verify the factorial structure of each scale: skills, tasks and interests. In search of greater parsimony, plots were created, grouping items of each subscale to obtain two sub-scores, for example, by adding even and odd items. Each sub-score was used as an indicator to measure the latent variable.

Figure 1 shows the confirmatory model for skills. Seven variables were evidenced: mathematical reasoning ability, physical, chemical, biological, visual-spatial, self-regulation-discipline, and leadership, as proposed by Alfaro-Barquero and Chinchilla-Brenes (2020). The model showed adequate goodness-of-fit indicators: CFI: 0.96, RMSEA: 0.08. Positive covariance was found between self-regulation-discipline and leadership and visual spatial ability. Similarly, an association was found between physical, logical-mathematical and chemical ability; in turn, chemical ability was correlated with biological ability.

Regarding the tasks, the proposed structure with 3 factors (AE, CE and MT tasks) was confirmed as shown in Figure 2. The goodness-of-fit indicators CFI .99 and RMSEA .06 were acceptable. The three factors showed negative covariances between them.

In the case of the interest scale, the proposed structure was verified: Interests by AE, CE and MT, with a good fit of CFI 1 and RMSEA .06. The interests of CE showed negative covariance with those of AE and MT, as detailed in Figure 3.

Previously, for final selection of items, the confirmatory factor analysis was performed for each subscale, showing reliability coefficients equal to or greater than .87 and discrimination of the items equal to or greater than .56. In addition, in each subscale, unidimensionality was evidenced according to the evaluated factor, and the goodness-of-fit indicators were acceptable in all cases: CFI greater than .95, RMSEA values equal to or less than .08, and Chi square values were relatively small. On the other

Table 1: Synthesis of the vocational profiles of the careers. Own elaboration

Vocational profile of Agricultural Engineering

Description	*Areas*	*Occupational tasks*	*Related areas*	*Interests and abilites*
Engineering design, management, preparation, maintenance and improvement of adequate and efficient agricultural processes, such as irrigation, drainage and energy. It is oriented to the use, management and conservation of soil and water resources, as well as the design and administration of machinery and resources in the solution of agricultural needs.	Production technologies Soil and water conservation and management Design, management and application of agricultural machinery	- Improving production with precision agriculture technology, automation trends and digitization. - Determining production management areas for irrigation, drainage and soil conservation. - Evaluating the characteristics of the soil. - Designing and evaluating irrigation systems for agricultural production and care of green areas. - Designing the drainage network for lands prone to flooding. - Designing and evaluating agricultural machinery. - Elaborating maintenance plans for agricultural machinery.	Topographic E. Civil E. Geography Environmental E. Comprehensive Water Resource Management Agronomy E. Forestry E.	**Interests** Agricultural production systems, irrigation and drainage Water supply Soil conservation Farm Equipment **Abilities** Mathematics, Physics and Chemistry Data synthesis and analysis Anticipate risks Teamwork Work in the field

Vocational profile of Teaching Mathematics in Technological Environments

Description	*Areas*	*Occupational tasks*	*Related areas*	*Interests and abilites*
It trains mathematics teachers, with the ability to analyze teaching-learning processes, educational innovation, integration of technological and pedagogical tools to promote a creative and critical environment for the development of logical-mathematical thinking.	Didactics and pedagogy Educative technology Math	- Understanding, applying and evaluating different psychopedagogical, methodological and evaluative approaches for the teaching of mathematics. - Lesson plaining and development of mathematic classes. - Use of technology to represent and model mathematical concepts and design of didactic activities. - Stimulate the development of mathematical skills and logical thinking. - Use and application of mathematical language. Relate mathematical concepts with everyday life situations.	Math Statistics Actuarial Sciences Education Careers Psychopedagogy Educational psychology	**Interests** Analysis of the educational system and teaching-learning processes Teaching and educational needs Educative technology **Abilities** Logical-mathematical reasoning Creativity and problem solving Empathy. Communication Interpersonal skills. Use of technology

Vocational profile of Computer Engineering

Description	*Areas*	*Occupational tasks*	*Related areas*	*Interests and abilites*
Discipline focused on the design, innovation, implementation and evaluation of both physical (hardware) and digital (software, firmware) technological products, as well as on the interaction and coupling between both systems (drivers, communication protocols), for solving problems or needs of society.	Analysis and development of software and hardware Digital systems Operating systems Computer architecture Embedded systems	- Designing of algorithms and data structures for software development. - Implementing low and high level programming codes and verifying proper operation. - Analyzing, designing and evaluating microchips, according to speed, energy consumption, purpose and structure. - Creating drivers to communicate the operating system with external devices. - Developing of monitoring programs for optimal use of applications and software programming for operating systems startup. - Defining specifications for the computer functions, the requirements for the execution of functions (storage, information to be processed, speed and inputs and outputs) and setting of instructions. - Designing, implementing and evaluating embedded systems, conceived to perform specific functions with high performance, in a more complex technological system, such as a car radio or video games.	Computing E. Systems E. Informatics E. Business Computer Software E. Information Technology Administration Electronics E.	**Interests** Technological innovation Software and hardware programming Microchip design Computers and digital systems Internet of things Electronics Data storage **Abilities** Mathematics Physics Chemistry Logical-mathematical reasoning Teamwork Creativity and innovation Technological update Problem solving Logical reasoning

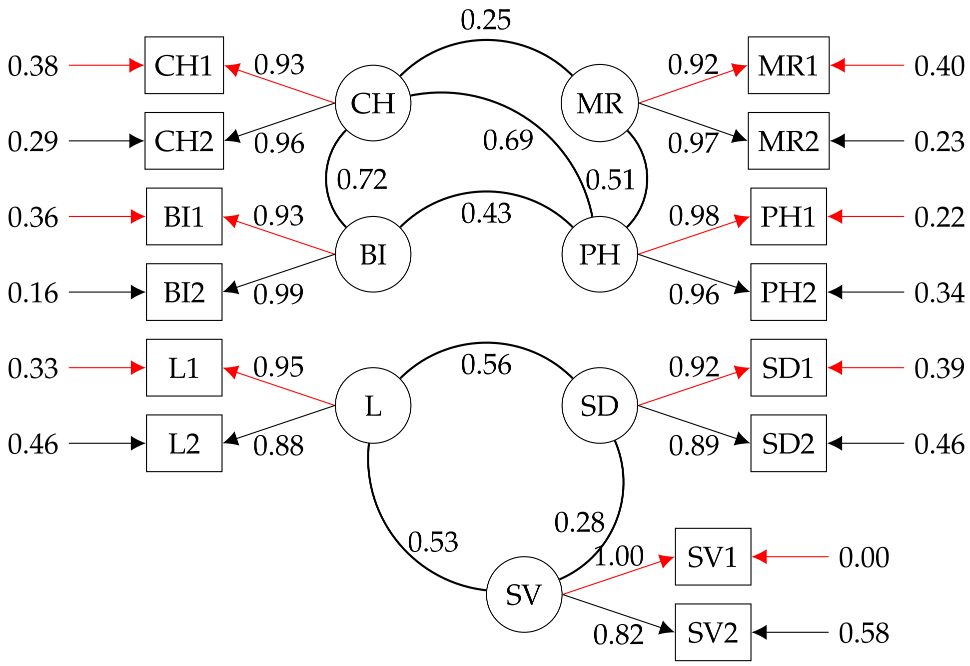

Figure 1: Confirmatory Factor Model for the skills scale. Goodness of fit indicators: CFI: .96, RMSEA: .08 and Chi square: $\chi^2(69) = 195.19$, $p = .00$, CH: Chemistry, BI: Biological, MR: mathematical reasoning, PH: Physics, L: Leadership, SD: Self-regulation-Discipline and SV: Spatial view. Own elaboration.

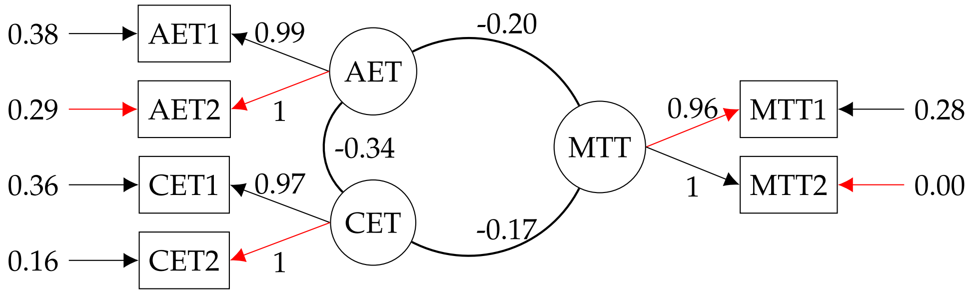

Figure 2: Confirmatory Factor Model for the tasks. Goodness-of-fit indicators: CFI: .99, RMSEA: .06 and Chi square: $\chi^2(6) = 11.75$, $p = .01$, AET: Agricultural Engineering Tasks, MTT: Mathematical Teaching Tasks, CET: Computer Engineering Tasks. Own elaboration.

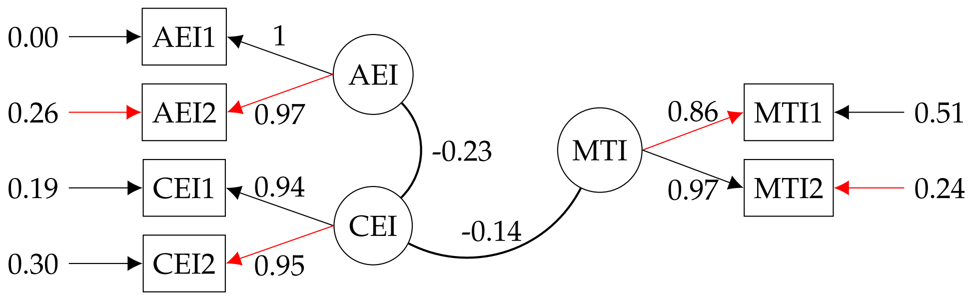

Figure 3: Confirmatory Factor Model for the interest scale. Goodness-of-fit indicators: CFI: 1, RMSEA: .06 and Chi square: $\chi^2(7) = 14.27$, $p = .05$. AEI: Agricultural Engineering Interests, MTI: Mathematical Teaching Interests, CEI: Computer Engineering Interests. Own elaboration.

hand, the factorial coefficients ranged between .54 and .97, showing very favorable indicators.

Once the scales were validated, the analysis of variance according to sex, career and level of vocational satisfaction was carried out. Significant differences were found in favor of women in the means of biological ability ($F(1) = 4.973$, $p = .027$, $\eta_{p^2} = .019$), discipline self-regulation ($F(1) = 16.275$, $p < .001$, $\eta_{p^2} = .058$), visuospatial ability ($F(1) = 19.515$, $p < .001$, $\eta_{p^2} = .069$), in preference for tasks ($F(1) = 4.160$, $p = .042$, $\eta_{p^2} = .016$), interests in Mathematics Teaching ($F(1) = 14.899$, $p < .001$, $\eta_{p^2} = .054$), and in Agricultural Engineering tasks ($F(1) = 4.507$, $p = .035$, $\eta_{p^2} = .017$). Men obtained higher averages in physical ability ($F(1) = 20.118$, $p < .001$, $\eta_{p^2} = .071$), in mathematical ability ($F(1) = 4.761$, $p = .030$, $\eta_{p^2} = .018$), and in preference for tasks ($F(1) = 40.857$, $p < .001$, $\eta_{p^2} = .134$) and interests in Computer Engineering ($F(1) = 42.712$, $p < .001$, $\eta_{p^2} = .140$). No significant differences were found in chemistry and leadership skills, vocational satisfaction, weighted average mark, or preference of interests for AE area.

The analysis results of variance by career showed significant differences in all the variables evaluated, except for leadership, self-regulation, discipline, and level of vocational satisfaction. Significant differences were evidenced in biological skills ($F(2) = 53.84, p < .001, \eta_{p^2} = .29$), physics ($F(2) = 49.91, p < .001, \eta_{p^2} = .28$), mathematical reasoning ($F(2) = 21.72, p < .001, \eta_{p^2} = .14$), visuospatial ability ($F(2) = 4.06, p = .018, \eta_{p^2} = .03$), chemical ability ($F(2) = 38.54, p < .001, \eta_{p^2} = .23$), in tasks ($F(2) = 128.46, p < .001, \eta_{p^2} = .50$) and interests ($F(2) = 53.10, p < .001, \eta_{p^2} = .29$) of the MT area, in the tasks ($F(2) = 274.45, p < .001, \eta_{p^2} = .68$) and interests ($F(2) = 160.36, p < .001, \eta_{p^2} = .55$) of the CE area and in the tasks ($F(2) = 445.29, p < .001, \eta_{p^2} = .77$) and interests ($F(2) = 194.11p < .001, \eta_{p^2} = .60$) of the AE area.

Subsequently, the Tukey test was used to compare significant differences according to career. Results indicate that the group of CE students showed significantly higher averages in physical ability ($p < .001$ MT y $p = .006$ AE) and in interests ($p < .001$ AE-MT) and CE tasks ($p < .001$ AE-MT) than the students of the other two careers. CE students also evidenced higher averages in mathematical reasoning than AE students ($p < .001$) and higher averages in chemical ability than MT students ($p < .001$).

MT students showed significantly higher means in the interests ($p < .001$ AE-CE) and tasks ($p < .001$ AE- CE) of their area, and higher scores in the mathematical ability than AE students ($p < .001$). Finally, AE students showed higher averages in biological skills ($p < .001$ CE - MT), chemistry ($p < .001$ CE - MT) and spatial vision ($p = .035$ MT $p = .031$ CE), and in AE interests and tasks than CE and MT groups ($p < .001$ CE- MT) and higher averages in physical ability than MT groups ($p < .001$).

On the other hand, the analysis of variance according to the level of vocational satisfaction showed significant differences for the students of the three careers in physical skills ($F(2) = 3.524, p = .031, \eta_{p^2} = .026$), leadership ($F(2) = 24.450, p < .001, \eta_{p^2} = .157$), mathematical reasoning ($F(2) = 8.191, p < .001, \eta_{p^2} = .059$), discipline self-regulation ($F(2) = 44.825, p < .001, \eta_{p^2} = .255$), spatial vision ($F(2) = 5.485, p = .005, \eta_{p^2} = .040$), and chemistry ($F(2) = 3.103, p = .047, \eta_{p^2} = .023$). No significant differences were found with biological ability or weighted average mark.

Subsequently, the Tukey test was used to compare significant differences according to the level of vocational satisfaction. Considering the cases where variables showed significant differences, those who were located in the high level of satisfaction showed significantly higher scores in the skills, tasks and interests related to their major than those who were located in the low categories, as detailed next.

In the case of the group of MT students, significant differences were found in the average of leadership skills ($F(2) = 7.728, p = .001, \eta_{p^2} = .205$), mathematical reasoning ($F(2) = 5.844, p = .005, \eta_{p^2} = .163$), discipline self-regulation ($F(2) = 11.968, p < .001, \eta_{p^2} = .285$) and MT interests ($F(2) = 7.595, p = .001, \eta_{p^2} = .202$), all with a high effect size. Visual spatial ability ($F(2) = 4.312, p = .018, \eta_{p^2} = .126$) and MT tasks ($F(2) = 3.141, p = .050, \eta_{p^2} = .095$) showed moderate effect size.

For AE, significant differences were found with high effect size in the average of physical abilities

$(F(2) = 5.613, p = .006, \eta_{p^2} = .147)$, discipline self-regulation $(F(2) = 10.912, p < .001, \eta_{p^2} = .251)$ and in the tasks $(F(2) = 13.163, p < .001, \eta_{p^2} = .288)$ and interests $(F(2) = 11.377, p < .001, \eta_{p^2} = .259)$ of AE. The effect size was moderate in mathematical reasoning $(F(2) = 5.166, p = .008, \eta_{p^2} = .137)$, chemical ability $(F(2) = 3.494, p = .036, \eta_{p^2} = .097)$ and leadership $(F(2) = 3.631, p = .032, \eta_{p^2} = .100)$.

For CE, significant differences were found with high effect size in leadership $(F(2) = 15,900, p < .001, \eta_{p^2} = .195)$ and discipline self-regulation $(F(2) = 20.431, p < .001, \eta_{p^2} = .238)$. It was moderate in physical skills $(F(2) = 4.925, p = .009, \eta_{p^2} = .070)$, mathematical reasoning $(F(2) = 4.405, p = .014, \eta_{p^2} = .063)$ and tasks $(F(2)) = 8.029, p = .001, \eta_{p^2} = .109)$ and interests $(F(2) = 6.249, p = .003, \eta_{p^2} = .087)$ of CE, and low in spatial visual ability $(F(2) = 3.076, p = .049, \eta_{p^2} = .045)$.

4. Discussion

The existence of seven skills associated with scientific-technological careers was confirmed; and so was the presence of three factors (MT-CE-AE) for the scales of tasks and interests, with adequate indicators of goodness-of-fit and reliability. The scales of tasks, interests and abilities showed a high effect size in the analysis of variance according to major and vocational satisfaction. This evidences the relevance of these variables in the choice of a career (Álvarez et al., 2014; Carrasco et al., 2014; Cepero, 2009; Espíndola, 2015; Hernández, 2001; Herrera & Burgoa, 2012) and provides support to existence of differences between vocational profiles according to career and affinity between students of same discipline in skills and interests (Fernández et al., 2019).

This affinity between professionals who share the same field of knowledge was high in Holland's RIASEC theory (Urribarrí et al., 2013), which, in a reduced and simplistic way (Reardon, 2017). It explains the preferences for professions and occupations, from the combination of the six personality typologies. On the contrary, this study assumes that there are specific vocational profiles for each career, and that preference for one discipline or another is explained by the degree of affinity between the requirements of each career and the characteristics of individuals; in terms of skills and inclinations for certain occupational interests and tasks, rather than for similar personality traits.

Vocational satisfaction is the result of the affinity between the characteristics of each career and personal traits (Benítez, 2010). This was evidenced in the study, since those who presented higher scores in the tasks, interests and skills of their discipline showed higher levels of vocational satisfaction. For its part, academic performance, as a source of extrinsic motivation, did not show an impact on vocational satisfaction.

As other authors have pointed out, perseverance and confidence in achieving the goal, as well as the probability of graduating, are affected by the interests and that a person assigns to the goal achievement (Dutta et al., 2015, Lent et al., 2004, Rodríguez et al., 2015, Schoenfeld et al., 2017). In this sense, the importance of graduating in a certain discipline will be associated with the level of vocational satisfaction of the student body and their degree of commitment to the major.

Results confirm that sexist stereotypes affect women's expectations, their choice of career, and work participation in science and technology (Lent et al., 2004, Rodríguez, 2016, Rosado, 2012). In fact, women showed preference for the area of Mathematics Teaching and they self-perceived as with lower physical and mathematical abilities than men, who showed preference for Computer Engineering. However, this is not consistent the evidence of academic performance and vocational satisfaction, where there are no significant differences by sex, evidencing the presence of gender biases.

Based on these findings, the importance of having more objective tools that provide university applicants with a clear and precise knowledge of different disciplines was shown. Similarly, such tools are essential to evaluate their preferences, considering skills, tasks and interests, instead of making decisions based on erroneous or prejudiced beliefs about the different areas of knowledge. Finally, profiles and psychometric scales elaborated in the study contribute to the level of domain of knowledge of the CIP theory, by offering inputs to deepen the understanding of the professions available in the scientific-technological area and favor self-knowledge for informed decision-making.

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