Comparing Data Analysis, Communication and Information Technologies Expertise Levels in Undergraduate Psychology Students

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***Abstract*—**Aims for this study: first, to compare the expertise level in data analysis, communication and information technologies in undergraduate psychology students. Second, to verify the factor structure of E-ETICA (*Escala de Experticia en Tecnologías de la Información, la Comunicación y el Análisis or* Data Analysis, Communication and Information´Expertise Scale*)* which had shown an excellent internal consistency (α= 0.92) as well as a simple factor structure. Three factors, Complex, Basic Information and Communications Technologies and E-Searching and Download Abilities, explains 63% of variance. In the present study, 260 students (119 juniors and 141 seniors) were asked to respond to ETICA (16 items Likert scale of five points 1: null domain to 5: total domain). The results show that both junior and senior students report having very similar expertise level; however, E-ETICA presents a different factor structure for juniors and four factors explained also 63% of variance: Information E-Searching, Download and Process; Data analysis; Organization; and Communication technologies.

***Keywords*—**Data analysis, Information, Communications Technologies, Expertise´Levels.

I. INTRODUCTION

THE International Society for Technology in Education, ISTE, in its National Educational Technology Standards (NETS-S) [1], had established six technology competencies required of students in our information society: Creativity and Innovation; Communication and Collaboration; Research and Information Fluency; Critical Thinking Problem Solving and Decision Making; Digital Citizenship; Technology Operations and Concepts. Creativity and Innovation competency includes demonstrating creative thinking, construct knowledge, and developing innovative products and processes; Communication and Collaboration proficiency includes use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others; Research and Information Fluency competency demands that the student apply digital tools to gather, evaluate, and use information; Critical Thinking Problem Solving and Decision Making is a competency related to the use of critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Digital Citizenship competency refers to understand human, cultural, and societal issues related to technology and practice legal and ethical behavior; finally, the Technology Operations and Concepts competency refers to demonstrate a sound understanding of technology concepts, systems, and operations.

Markauskaite [2] cites a serial of standards for students (Candy, 2004; ETS, Educational Testing Service, US, 2002; ISTE, International Society for Technology in Education, US & Canada, 1998) of current ICT (Information and Communication Technologies), and points out that the majority of them are based on a double vision of the ICT literacy which integrate cognitive and technical capabilities. According to this approach: ‘‘ICT literacy is using digital technology, communication tools, and/or networks to access, manage, integrate, evaluate and create in order to function in a knowledge society (ETS, 2002, p. 16.) ICT literacy is the set of capabilities required for the successful completion of cognitive information and ICT-based tasks. ICT literacy, therefore, is an interaction of two kinds of capabilities: (a) general cognitive and (b) technical.” [2] p. 548.

The capabilities technical as well as cognitive included in a ICT literacy [2] are nine. Next will be presented with their technical definition only:

1. Plan.- To use planning and decision – support tools, etc.
2. Access.- To work within the desktop environment, navigate and search digital resources, maintain a computer, etc.
3. Manage.-To perform common operations within software packages, manage data using spreadsheets, design databases, etc.
4. Integrate.- To solve problems using spreadsheets and modeling software, manipulate databases, etc.
5. Evaluate.- To evaluate relevance of digital resources, information and tools, etc.
6. Create.- To create graphics, documents, presentations and web pages, etc.
7. Communicate.- To publish and deliver results of a research activity using ICT presentation tools and networks, etc.
8. Collaborate (interpersonal capabilities).- To communicate via e-mail and other network tools, collaborate in virtual learning environments, etc.
9. Reflect and judge (metacognitive capacities).- To use personal management and reflection tools, etc.

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II. Purpose of the Study

In our information and knowledge´s society, one of the keys for development and growth in the countries is to invest in the human capital. In this age, as never before, it is necessary for every country to train its people in the ICT´s (Information and Communication Technologies) proficient management. In the course of the world´s social development, there have been necessary revolutions; in the same way that an industrial revolution was necessary in its moment, in our current times technological one has been necessary. Also, the society is accommodating to this new social, economical and political order and the new generations are been recognized as the Net generation [3]; today our world is a global one thanks to the technology. However, organizations such as the OECD (Organization for Economic Co-operation and Development), pose this question *Are students ready for a technology-rich world?* The OECD [4] points out, for instance, that "despite its high level of economic development, Japan ranks in the bottom 10 countries (together with Turkey, Mexico, Tunisia, Latvia, etc.) with only 15% of [high school] students with access of 'more than five years' of ICT access in PISA 2003." p.1. On the other hand, the OECD indicates that the vast majority of these students are able to tackle basic ICT tasks and are generally confident about their Internet abilities. While fewer can perform high-level tasks unaided, most think they could do so with some help. Generally, students in all participating countries in the OECD report high confidence in using ICT, with the majority saying they are able to perform 17 of the 23 tasks specified very well by themselves. The OECD also points out that students are relatively more confident performing routine tasks than Internet tasks or high-level tasks on a computer, although even in the case of the latter, most students thought that they could do each task at least if they had some help.

Now, what do higher education students report about their own competences and skills to manage and use ICT? How confident they feel using different ICT? In order to contribute to the knowledge and provide new empirical evidence about how higher educations student, specifically from a developing country (México), feel about these two former questions, a double purpose leaded this study: first, to measure the proficiency level on ICT in a sample of Mexican psychology undergraduate of the National Pedagogic University, a public University in Mexico City, reported by the students in a psychometric instrument, E-ETICA, and compare this proficiency level in junior and senior students; second, to add evidence to the construct validity of the E-ETICA scale which was created to measure proficiency in a variety of ICT [5].

Cronbach and Meehl [6] establish that construct validity is involved whenever a test or instrument is to be interpreted as a measure of some attribute or quality which is not "operationally defined." The purpose of the construct validity is *to validate the subjacent theory* to the evaluation system and the same measurement (test or instrument), indicating in what degree the test is an adequate measure of the construct (concept) and in what degree hypothesis derived from this can be confirmed using that test or instrument [7].

Conbach and Mheel [6] denote that many methods can be used in construct validation: a) *Group differences*, if our understanding of the construct lead us to expect two groups differ on the test, this expectation may be tested directly. Only coarse correspondence between test and group designation is expected. Too great correspondence between the two would indicate that the test is to some degree invalid, because members of the groups are expected to overlap on the test; b) *Correlation matrices and factor analysis*, if two tests are presumed to measure the same construct, a correlation between they is predicted. A matrix of inter-correlations often denotes profitable ways of dividing the construct into more meaningful parts; so a factor analysis is a useful computational method in such studies. Cronbach and Mheel [6) cite to Guilford who says about the factor analysis it is an exact and stable description; it is economical in explanation; it conduces to the creation of pure tests which can be combined to predict complex behaviors; c) *Studies of internal structure*, for many constructs evidence of homogeneity within the test is relevant in judging validity. Item – test correlations and certain reliability formulas describe internal consistency. Only if the subjacent theory of the trait being measured calls for high item correlations do the correlations support construct validity; d) *Studies of change over occasions*, the stability of tests scores (test-retest, Catell ´s N-technique) may be relevant to construct validation.

Gómez [7] also enunciates as methods for bringing evidence of construct validity, the analysis of the relationship [of the test] with external variables. Among these analyses can be included studies of concurrent and predictive validity, convergent and discriminate analysis, experimental studies, differential studies and structural equations modeling.

III. Theoretical Framework

A. The ICT Literacy: The Beginning

Merely two decades and half ago in 1985 literacy was defined by Kozol as the ability to read at a fifth – grade level. Two years later, in 1987, literacy was defined as the capacity to function in an increasingly complex society, in part because of the expanding computer capabilities; functionally illiterate people were defined as those who were unable to manage the information necessary for leading productive, meaningful lives [8].

As Kuhlthau [8] at that time noticed, computers transformed traditional means of producing, storing, organizing and gaining access to information. Today things in this respect have not changed, except that we can add more functions to the computers such as communicating, analyzing, presenting information for a variety of purposes.

How was defined at that time to be literate in information society? Information literacy was said to be closely tied to functional literacy "and involves the ability to read and to use the information for every day life. It also involves recognizing an information need and seeking information to make informed decisions. Information literacy requires the ability to manage complex masses of information generated by computers and mass media, and to learn throughout life as technical and social changes demand new skills and knowledge" [8], p. 8 . Literacy involves process skills which are applied for a particular purpose. Reading and writing are skills used for understanding, learning, and communicating. With these skills we can be able to learn concepts and communicate ideas.

B. The Current Time

Today the ICT literacy is judged not only by the technical capabilities in the management of the technology but also by the general cognitive abilities related to each one of these cognitive skills. In this respect, Markauskaite points out that "the majority of current ICT standards for students are based on the 'blended' concept of ICT literacy, which integrates technical capabilities to use ICT tools with the cognitive capabilities of problem solving and information processing" [2] p. 548.

Among these cognitive abilities are, for instance, selecting appropriate techniques and tools, obtaining information from various media and sources *(Access* technical capability) or defining evaluation criteria, judging the quality, uselfulness and relevance of information, making choices, etc., (*Evaluation* technical capability.)

Vitolo and Coulston [9] also identify a variety of organizations that had proposed ICT literacy definitions. Among these organizations can be listed the National Research Council (1999), American Library Association (1989; 2000), and the Information Technology Association of America (2000). They also indicate the necessity for a better understanding about the spectrum of information literacy in such way that: "a clean paradigm shift can be made, from our current state of strife and confusion to a new set of well-defined, shared expectations across the culture". They cite the ALA (American Library Association) that in 1989 defined four aspects to information literacy: 1. The ability to recognize when information is needed; 2. The ability to locate the needed information; 3. The ability to evaluate the suitability of retrieved information, and 4. The ability to use effectively and appropriately the needed information.

Students in higher education are using the ICT for educational purposes and, seemingly, with very good results in the cooperative and collaborative learning field [10]; Laird and Kuh affirm that in college campuses across the USA students, faculty and administrators are using computers, internet and other forms of information technology for various educational purposes; e-mail, the World Wide Web (WWW), and word processors are no longer flashy new tools only for some privileged few. The authors indicate that: "The results from studies of student information technology use for academic purposes are promising. For example, the Institute for Higher Education Policy (1999) reported that to use e-mail for academic work grew from 8% in 1994 to 44% by 1998. The percentage of courses using the Internet doubled from 15% in 1996 to 30% by 1998. A more recent national survey called Student Monitor found that 84% of college students owned a computer and that 99% used the Internet, with 66% doing so daily. Students appear to use the Internet to communicate with others and to find materials and assistance with their coursework (Hu and Kuh, 2001; Student Monitor, 2003) [10], p. 212.

C. Self- Efficacy Theory and its Relation to ICT ´expertise

This study is based on the social cognitive and self-efficacy theories [12], [13]. Human behavior is defined by the social-cognitive theory as a product of an interaction between personal factors, behavior and the environment [12]. Self-efficacy -a key construct of the social-cognitive theory- [13] refers to a belief in one's own capabilities to organize and execute the course of action required to attain a goal. Self-knowledge of one's self-efficacy is based on four main sources of information: (a) previous experience, (b) observation of the performance of others, (c) social persuasion from peers, colleagues and others, and (d) psychological and emotional states from which people judge their capabilities. Psychological factors such as level of motivation, affective states and real actions [13] are, according with Kurbanoglu, cited by [2], specially important to the ICT-related capabilities. The author sustains that: "If a person feels competent and confident in her/his own capabilities to undertake an information-based problem-solving activity and to use for this activity various ICT tools, it is more likely that s/he will try to solve such a problem" p. 553. For this reason, in this study is considerate that self-efficacy and the results of it self-assessment are as relevant and useful as the results of an external assessment of actual human knowledge and capability.

IV. Method

A. Study and Design

This was a descriptive study which compared the Information and Communication Technologies proficiency´ levels in psychology juniors and seniors students.

The study was based on a non-experimental design or ex-post-facto descriptive.

B. Aims

The aims of this study were two: first, to compare the expertise level in data analysis, communication and information technologies in junior and senior psychology students. Second, to verify the factor structure of E-ETICA (*Escala de Experticia en Tecnologías de la Información, la Comunicación y el Análisis)* –construct validity- obtained in a previous study.

C. Participants

260 psychology undergraduate, mostly women (80%), 119 juniors and 141 seniors, participated voluntarily in this study. Sampling was intentional.

D. Instruments

The Escala de Experticia en Tecnologías de la Información, la Comunicación y el Análisis de datos (E-ETICA- or Data Analysis, Communication and Information Technology Expertise Scale) [5] was applied to this student sample. E-ETICA is a 16 items Likert type scale, with five answer options: 1. Null or very little domain to 5. Complete domain. The scale is a self-report about the Information and communications technologies proficiency´ level that participants considered to have with respect to the Information and communications technologies. Some examples of the items are: “To do hyperlinks (between text, images, graphics, photos, etc.,) for instance, for a demonstration”, “To use statistical packages for the data analysis (as SPSS, SYSTAT, CSS, etc”, “To do efficient electronic material searching (e-books, e-journals, etc.) in the Internet”. The psychometric properties of E-ETICA have been proved [5], including its internal consistency (α = 0.91) and its simple factorial structure with a sample (N= 117) of senior students. On that previous study, an Exploratory Factor analysis with varimax rotation conducted to a three factors structure: Factor I was named High Complexity Technologies and includes technologies of certain complexity such as statistical packages, qualitative analysis software, map conceptual software, etc; Factor II, Low Complexity Technologies, includes more simple technology tools such as the Power Point program, text processors, Excel package, e-mail, etc.; and Factor III, E- Searching and Downloading skills, that includes e-searching skills in the WWW, and downloading skills of e-material and photos. These three factors explain together the 63% of variance.

Table I shows the factor structure of E-ETICA obtained in the previous study: the inter-item correlation loads by factor and its alphas.

TABLE I
FACTOR STRUCTURE OF E-ETICA

Technologies	Complex Tech Factor I	Basic Tech Factor II	Searching/ Download Skills Factor III
Statistical Packages (SPSS, CSS)	.775		
Qualitative Analysis Software	.726		
Conceptual Map Software	.688		
Web pages design	.663		
Blogs and Wikis	.648		
Hyperlinks	.542		
Power Point Program		.745	
Text Processors		..695	
Excell Package		.666	
E-mail		.649	
Cell- phone		..640	
Graphics Creation Programs		.595	
WWW Searching			.817
E- books, E-material Download			·.746
Photos download to computer			.709
Software and Programs Downloa			.654

Factor I α = 0.89; Factor II α = 0.88; Factor I α = 0.89.

V. RESULTS

All of the statistical analyses were executed with SPSS (Statistical Package for the Social Sciences) ver. 17.

A. Descriptive Statistics

141 juniors, 127 women and seven men (seven did not answer), 119 seniors, 85 women and 28 men (six did not answer), participated in this study.

B. Internal Consistency

The internal consistency of E-ETICA was very good (N= 141, α = 0.92; N= 119, α = 0.875). All the items were kept since the inter-item correlations were between 0.522 to 0.730 and between 0.461 to 0.724 for juniors and seniors, respectively.

C. Exploratory Factor Analysis

First, an exploratory factor analysis was executed for the total sample (juniors and seniors, N= 260) obtaining a three-factor structure as in the previous study [5]. However, this structure was not theoretically coherent. As second step, two exploratory factor analyses were executed by the principal components method and varimax rotation, for juniors and senior´s samples separately.

Senior sample. The KMO measure of sampling adequacy was 0.91 and Bartlett´s test of sphericity was highly significant (p <.000) indicating the appropiateness of correlations for the factor analysis. For seniors, the factor structure of E-ETICA was kept as in the first study, showing the same three previous factors: Factor I. Complex Technologies (six items, α= 0.83); Factor II, Basic Technologies (six items, α= 0.85); Factor III, E- Searching and Downloading Skills (four items, α= 0.84), including in each factor exactly the same items as in the first study. The three factors together explained 63% of variance, being the first factor which explained most of it (46.7%.)

Juniors Sample. The KMO measure of sampling adequacy was 0.841 and Bartlett´s test of sphericity was highly significant (p <.000) indicating the appropiateness of correlations for the factor analysis. For juniors, four factors resulted: Factor I, Searching, Downloading and Processing of E-Information (five items, α= 0.82); Factor II, Data analysis (four items, α= 0.73); Factor III, Communication technologies (four items, α= 0.70); and Factor IV, Organization and Presentation of information (three items, α= 0.73). The percentage of variance explained by the four factors was 62.6. Each one of them explained the next percentage: Factor 1, 35.92; Factor II, 11.8%, Factor III, 7.88%; and Factor IV, 7.0%

The Table II presents the factor structure of E-ETICA for juniors.

TABLE II
FACTOR STRUCTURE FOR E-ETICA, JUNIORS SAMPLE

Technologies	Factor 1	Factor 1I	Factor 1II	Factor 1V
Software download	.749			
E-searching	.736			
Hyperlinks	.697			
Web pages design	.672			
E-material download	.663			
Qualitative analysis pro		.793		
Statistical packages		.793		
Excell program		.632		
Blogs & wikis	.196	.593		
Cell-phone			.783	
E-mail			.738	
Photos			..639	
Text Processor			.518	
Power point				.759
Conceptual Maps				.720
Graphics Program				.626

Factor I: Searching, Downloading and Processing of E- Information; Factor II, Data analysis; Factor III, Communication technologies; and Factor IV, Information´ s organization and presentation.

As can be seen in the Table II, Factor I reunites those technical capabilities for the Internet´ use related to searching, downloading, processing, and creating the information. Factor II encloses those technologies indicated for the data analysis. Factor III, includes communication technologies; and finally, Factor IV reunites those programs utilized for the presentation and organization of the information. The four factors are theoretical and logically coherent.

D. Means by Scale

In order to: 1. Compare the means in the factors or scales that the two groups of students, juniors and seniors obtained, since the factors have different number of items; 2. Interpret in an easier way the mean in terms of the level that the students report to have in each factor, the same scale answers´ options will be used, which are 1. Null or not domain; 2. Some domain; 3. Enough domain; 4. Much domain; 5: Very much or total domain, was obtained, in the first place, the mean by case by scale; then, the mean of those means by scale, was obtained. Tables III and IV next present the original means by scale and the mean of means by scale.

TABLE III
MEANS BY SCALE - SENIORS

Factor or Scale	No. Items	Mean	SD
High Complexity Technologies	6	11.31	6.11
Low Complexity Technologies	6	22.81	5.56
E-searching and Downloading skills	4	14.00	5.14
ME High Complexity Technologies	6	1.88	1.01
ME Low Complexity Technologies	6	3.80	.927
ME E-searching and Downloading	4	3.50	1.287

ME= Mean of means

Table III shows that seniors report having much domain (Mean= 3.80) in Low Complexity Technologies as well as in Searching and Downloading E-material, but low domain in High Complexity Technologies.

TABLE IV
MEANS BY SCALE - JUNIORS

Factor or Scale	No. Items	Mean	SD
Searching, Downloading and Process	5	14.73	5.18
Data analysis	4	8.23	3.28
Communication technologies	4	16.15	3.57
Organization and Presentation	3	9.28	2.89
ME Searching, Downloading and P.	5	2.95	1.036
ME Data analysis	4	2.06	.822
ME Communication technologies	4	4.04	.894
ME Organization and Presentation	3	3.09	.963

ME= Mean of means

Table IV shows that juniors report having high domain in Communication Technologies as cell phone, e-mail, etc.; medium domain in Information´s Organization and Presentation Programs like Power Point, Conceptual Maps an Graphics and Searching, Downloading, Processing and Creating E- Information; and low domain in Data analysis Programs as Statistical, Qualitative and Excel Programs.

Both groups of students, therefore, coincide in the domain´s level that they report having in the technologies that we have considered as being of high and low complexity: Juniors and seniors report having high domain for technologies and technical capabilities of low complexity and low domain for technologies and technical capabilities of higher complexity.

The next aspect worthy of comment is the different factor structure of E-ETICA for juniors and seniors. In the first ones, in one same factor (Factor 1) all those technologies (programs for the analysis of quantitative and qualitative data, and the Internet with its possibilities for communicating and creating hypertext) are reunited, of which management implies a certain level of difficulty, especially for the statistics programs. In a second factor those technologies of which management can to mean a lower level of difficulty are reunited, such as programs for the presentation of information, data analysis in Excel, and communication; students are very habitué to two of these technologies: cell phone and e-mail. Finally, the third factor encloses those technical capabilities related to searching and downloading electronic material, something that students also do regularly.

Meanwhile seniors seem to synthesize the technologies that we have considered as technologies of high complexity, in only one factor, juniors seem to decompose this factor in its components: Data analysis (Factor II); Factor III, Communication technologies (Factor III), Information´ s organization and presentation (Factor IV). On the other hand, for juniors, as well as seniors, we found a factor reuniting the searching and downloading of electronic material skills.

VI. DISCUSSION

Meanwhile the same factor structure was not obtained for the two students samples, juniors and seniors, this result is not interpreted in this study as an inconsistency (lack of construct validity) with the previous factor structure for E- ETICA [5], in which a simple three factors structure for the items included was obtained, for two reasons: First, the same three-factor structure of E-ETICA was obtained with two different samples of senior students (the previous and the current studies); besides, the three factors present a very good reliability. Second, in this study is interpreted this new four factors structure obtained with the juniors sample rather as the probable manifestation of a subjacent cognitive ability to the technical capabilities, of a lower order (*analysis*: of elements, relationships and organizational principles) than that shown by the seniors sample when including all of the higher complexity technologies in one single factor, and all those of some low complexity technologies, in another single factor (*synthesize*: as derivation of a set of abstract relations), according with the Bloom´s knowledge taxonomy [11].

The former could mean that E-ETICA can measure as technical capabilities as, at least to some degree, cognitive abilities. In this respect, we cite to Markauskite [2] who comments: "ICT literacy is the set of capabilities required for the successful completion of cognitive information and ICT-based tasks. ICT literacy, therefore, is an interaction between two kinds of capabilities: (a) general cognitive and (b) technical. Both capabilities cover similar areas of problem solving and other generic activities". Nevertheless, the author points out that there is disagreement among the researchers about the relationships between general cognitive and technical aspects of ICT literacy. On one hand, it can be hypothesized that there are primarily horizontal relationships between the ICT-related technical and general cognitive capabilities in each area of problem solving (e.g., plan, access, manage, integrate). Then *various problem-solving capabilities are integrated and applied* in a broader framework of the problem-solving process. Markauskite cites the example of an ICT literate student, who is able to integrate information should also possess both the cognitive capabilities needed to summarize, compare, contrast, etc. information and the technical capabilities to manipulate this information using various ICT tools. From this perspective, then, the cognitive and technical capabilities *cannot be* developed separately. In contrast, a student could develop good capabilities in one area of ICT literacy (e.g., integrate), while not necessarily acquiring adequate capabilities in all other areas (e.g., plan, communicate). In other contrasting theory, other authors suggest that ICT-related technical capabilities are an independent component of more generic information-based cognitive capabilities, Kurbanoglu, 2003, cited by [2]. According with this approach, it can be hypothesized that there are primarily vertical relationships between various areas of cognitive and technical capabilities. For example, a student could develop cognitive capabilities in all areas of ICT literacy, without having developed relevant technical skills to use ICT, and vice versa. In the empirical study of Markauskaite it was found that general cognitive and technical capabilities are two separate areas of ICT literacy; however, both areas shared one of the components found in such study named "basic ICT capabilities" which included abilities related with to operate a computer, use basic software applications, manage files and communicate via network [2].

Despite the results of the Markauskite´s study, would be interesting to continue investigating about what E-ETICA can do in terms of detecting and measuring also cognitive abilities. In order to accomplish this, and to provide evidence for the E-ETICA construct validity, will be suggested by this study, among other actions, for instance, to correlate E-ETICA with validated scales that measure general cognitive capabilities in ICT. One of these scales could be the ICT Literacy [2] which is a six-point Likert scale (0–5) that measures the strength of self-efficacy beliefs about as technical as cognitive skills. Also, to correlate E-ETICA with some external assessment of the actual cognitive abilities related to the ICT use. A third method could be to apply E-ETICA to freshmen and sophomore, because could be hypothesized, according with the subjacent theory, that these students would show maybe lower abilities with respect to the Bloom´ s knowledge levels taxonomy than those shown by juniors and seniors.

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