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Scientific reasoning skills and patterns of use of Information and Communication Technologies. The case of the students of the Universidad de Santander (Valledupar, Colombia)

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Abstract. This research establishes the relationship that has had the development of the skills of scientific reasoning and the patterns of use of tools and resources of information and communication technology (ICT). For that, it is necessary to use Lawson Test and to have into account ICT National Standards for students that USA International Society for Technology in Education (ISTE) suggest. Also, this paper is tackled from a non-experimental design featuring a correlational – transectional range. The population consists of 2035 students from a higher education institution of the Colombian Caribbean coast. Besides, stratified random sampling is used defining, defining strata and a representative sample for academic programs. Personal survey was used to collect information. The existence of relationship between scientific reasoning skills and patterns of use of information and communication technology was confirmed.

1. Introduction

When talking about scientific reasoning skills, reference is made to the existence of formal operations, which precisely, facilitate the elaboration of propositions in the individual, since to demonstrate scientific thought, abstraction, propositional logic, probabilistic notions are indispensable, among other factors, for its exercise. In this way the individual is able to use the eight formal operating schemes of combinatorial operations, proportions, combination of two reference systems, notion of mechanical equilibrium, notion of probability, notion of correlation, multiplicative compensations, forms of conservation, which are acquired in a solidary or homogeneous way from the domain of formal thought [1].

Lawson, in criticizing Piaget's postulates, argued that the development of scientific thought is associated with processes of instruction [2]. According to this author, the Piagetian approach to learning has several edges "[...] different levels of learning analysis, from behavior, information, representation and knowledge from the point of view of different psychological theories". Thus, Lawson places students in three categories of reasoning: concrete operations, transition operations and formal operations; evaluating six aspects of scientific reasoning: conservation of physical magnitudes, proportional thinking, identification and control of variables, probabilistic thinking, correlational thinking and combinatorial thinking [3].

On the other hand, the enormous accumulation of information, led to a series of practices that stopped being exclusive of science to become the whole of society. Thus, knowledge ceased to be something exclusive to a small group of people dedicated to science, and began to have an influence on each of the dimensions of human life: the everyday, the work, the family, etc. In this way, since the Century of Lights (eighteenth century) began to form what is known as the knowledge society. The notion of the Knowledge Society is characterized by the ability to make use of information through analysis or critical reflection to generate the knowledge necessary to promote individual and collective human development. In addition, this notion incorporates a network construction of society that promotes autonomy and encompasses the notions of plurality, integration, solidarity and participation [4].

In this sense, the development of digital technologies, added to the Knowledge Society, has made the relationship between man and his environment change according to the use given to information and communication technology. This relationship is deepened day by day according to technological advances, in such a way that the new generations are more integrated with these advances. They are known as digital natives. The digital natives are those people - mostly young people - who were born immersed in technology and live with it since they were very young, so they are used to it and are very skilled at using it [5].

For this, the Colombian state, occupies a position, not very privileged, in terms of indicators that measure, among others, the degree of preparation for the use of ICTs, with respect to other countries, which count and develop a clear policy against ICT. Those countries that have had policies that have explicitly pointed to the development of ICT and competitiveness, and that have been sustained over time, tend to see it reflected in these measurements. Chile, for example, is a country that has had a great commitment not only to economic policies aimed at increasing its competitiveness, but has also focused attention on the appropriation and use of ICT.

Likewise, Costa Rica has also had a very proactive approach in the use of these technologies. Although these indices constructed in this way have some deficiencies, as in many cases they are outdated, or based on perceptions and not on measurable variables, they still allow for comparisons between countries and draw attention to aspects that must be addressed. to get better.

Thus, the Ministry of Information Technologies and Communications (MINTIC) announced in December 2017, the first results of the Digital Economy Observatory: "The Observatory analyzed the adoption and management of mature digital technologies, such as broadband , mobile technologies and management platforms, and advanced digital technologies, such as cybersecurity, cloud computing, internet of things, robotics, big data, artificial intelligence, etc., taking into account the size of companies, the economic sector and the region [6].. This is how, in 2018, MINTIC is concerned about contributing with ICT to the transformation of education, since it considers as its objective 3 "Promote ICT as a platform for equity, education and competitiveness", trusting that what is established at the educational policy level for the use and access of ICT in society, contributes to improving the country's underprivileged position. In this sense, the objective of the work is to determine the relationship between the scientific reasoning skills and the patterns of use of information and communication technology of the students of a higher education institution of the Colombian Caribbean Coast.

2. Experimental

2.1. Method

The research was developed under the foundations of the quantitative, descriptive, field, transectional and non-experimental approach according to the proposal of Hernández and Others (2014) [7]. Some of its elements are described below.

2.2. Participants
The population is constituted by the students of a higher education institution of the Colombian Caribbean Coast, which amount to 2035 students. The students are distributed in 8 academic programs offered by the institution (7 professionals and 1 technology): Financial Administration, Physiotherapy, Industrial Engineering, Bacteriology and Clinical Laboratory, Psychology, Law, Veterinary Medicine and Zootechnics and Technology in Graphic Design and Advertising.

When using stratified random sampling, III Strata were defined (I: 1st to 3rd Semester, II: 4th to 6th Semester, III: 7th to 8th - 10th Semester.) Bearing in mind that the population is 2035 students and expecting a standard error of less than 0.04 and a confidence level of 0.95, the sample size is 464 students, distributed in the three strata, and Table 1 shows the distribution of the samples by cohort. At the beginning of the race, the distribution of the sample was 43%, in the middle of the race the distribution of the sample was 34% and at the end of the race the distribution of the sample was 23%.

Table 1. Distribution of the sample by cohort

	Frequency	Percentage
Early in the race	271	43%
In the middle of the race	209	34%
At the end of the race	146	23%
Total	626	100.0

2.3. Techniques
For the collection of information, the Survey was used, considered the most used quantitative technique for obtaining primary information; Among the different types of surveys, the personal survey was chosen for this research, where there is direct contact between the interviewer and the interviewee [7].

2.4. Instruments
Lawson questionnaire (standardized psychometric test). The scientific reasoning skills in the students were identified using a modified version of the Scientific Reasoning Test in the Lawson Classroom (1978). The validity of the original test was established in several studies (for example, Lawson, 1978, 1979, 1980, 1982, 1983, 1992, Lawson, Weser, 1990, Lawson, Baker, DiDonado, Verdi, Johnson, 1993) [9].

The modified test includes 24 multiple-choice questions that identify reasoning patterns related to: Conservation of physical magnitudes, proportionality thinking, identification and control of variables, probabilistic thinking, correlation and probabilistic thinking and combinatorial thinking. Similarly, the results of the Lawson Test allow students to be placed in three categories of reasoning: specific operations, transition operations and formal operations. This test was designed in such a way that the approaches formulated to the students do not require a complex understanding of contents, which reduces any type of interference and allows to improve the measurement of basic reasoning skills. The validity of the modified version was established by Lawson (1999) and Lawson, Clark, Cramer-Meldrum, Falconer, Seaquist, Kwon (2000) [9].

Questionnaire about the use of technology. To determine the patterns of use of technology by the students in the sample, a questionnaire of 24 multiple-choice questions was designed that gathers information related to: Type of resources and technological tools that it uses, hours and days of use of ICT to the week, places of access and use of technology, habits of use of ICT for learning, use of ICT in teaching-learning activities in the institution, assessment of learning and use of technology.

With this information will be reported the patterns of use of information technology and communication: Operations and concepts of computer science, knowledge of the Internet, use of ICT in the planning of learning, research and management of digital information for learning and

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general ICT competence.

2.5. Data analysis

For the analysis of the following results we proceed first to make descriptive statistics such as frequency and percentages.

We used a Kolmogorov-Smirnov test, of goodness of fit, which serves to test the null hypothesis in which the distribution of a variable fits a certain theoretical distribution of probability. If the value of the criterion or level of significance is very small (less than 0.05), the hypothesis of normality is rejected and it is concluded that the scores of that variable do not adjust to a normal distribution. The results of the Kolmogorov-Smirnov test indicate that the hypothesis of normality is rejected with a critical level of $p < 0.005$, and we conclude that the scores of the variables do not conform to a normal distribution. That is, that nonparametric statistics must be used to analyze the data.

Then a Spearman correlation was made. The decimal number obtained by relating these variables indicates the strength of relationship and statistical significance of the same, thus from the numerical value of the correlation coefficient obtained, it is considered that values close to zero denote a weak relationship, while that approached + 1 or -1 indicate a stronger relationship. The correlation scores that showed a level of significance less than or equal to .05 were taken into consideration.

In order to check each of the hypotheses raised in this research, a Kruskal-Wallis H-test was used. It is an extension of the U Mann-Whitney test is the nonparametric analog of the one-way analysis of variance (ANOVA) and detects differences in the location of distributions. The statistical software SPSS was used to perform these analyzes.

3. Results and Discussion

Below is an analysis of the main results.

In determining the relationship between scientific reasoning skills and the patterns of use of information and communication technology of students who are beginning their careers at a higher education institution in the Colombian Caribbean Coast, it is observed that there is a significant relationship between the operations pattern and computer concepts and the proportionality thinking skills ($r = .183$, $p < 0.010$); correlational and probabilistic thinking ($r = .229$, $p < 0.010$); Combinatorial thought ($r = .127$, $p < 0.050$). In addition, there is a significant relationship between the internet knowledge pattern and the identification and control of variables ($r = .120$, $p < 0.050$); probabilistic thinking ($r = .143$, $p < 0.050$); Correlation and probabilistic thinking ($r = .190$, $p < 0.010$).

When determining the relationship between scientific reasoning skills and the patterns of use of information and communication technology of students who are in the middle of their higher education careers in the Colombian Caribbean Coast, it is observed that there is a significant relationship between the pattern of operations and computer concepts and the conservation abilities of physical magnitudes ($r = .191$, $p < 0.010$); Proportionality thinking ($r = .158$, $p < 0.050$); identification and control of variables ($r = .221$, $p < 0.010$); probabilistic thinking ($r = .274$, $p < 0.010$); correlational and probabilistic thinking ($r = .194$, $p < 0.010$); combinatory thinking ($r = .159$, $p < 0.050$). There is also a significant relationship between the Internet knowledge pattern and probabilistic thinking ability ($r = .247$, $p < 0.010$). Similarly, there is a significant relationship between the pattern of use of ICT in the planning of learning with the conservation skills of physical magnitudes ($r = .136$, $p < 0.050$); identification and control of variables ($r = .183$, $p < 0.010$); probabilistic thinking ($r = .184$, $p < 0.010$).

In determining the relationship between the scientific reasoning skills and the patterns of use of information and communication technology of students who are at the end of their careers at a higher education institution in the Colombian Caribbean Coast, it is observed that there is a significant relationship between the pattern of operations and computer concepts and the ability to conserve physical quantities ($r = .234$, $p < 0.010$). There is also a significant relationship between the knowledge pattern of the internet and the conservation skills of physical magnitudes ($r = .288$, $p < 0.010$); identification and control of variables ($r = .186$, $p < 0.050$). Similarly, there is a significant relationship between the pattern of research and management of digital information for learning and the ability to think correlational and probabilistic ($r = -.164$, $p < 0.050$).

When determining the differences that exist between the scientific reasoning abilities among the students' scores in the different cohorts, there are significant differences in probabilistic thinking ($X2 = 6.039$, $gl = 2$, $p < 0.050$), because as students are advancing in their careers have a greater probabilistic thinking. That is to say that the hypothesis that there is a significant difference of the scientific reasoning ability "Probabilistic thinking" between the scores of the students in the different cohorts is approved.

When determining the differences that exist between the patterns of use of information and communication technology between the scores of the students in the different cohorts, there are significant differences in the use of ICT in the planning of learning ($X2 = 15.583$, $gl = 2$, $p < 0.050$), because as students progress in their careers they have a greater planning of their learning. That is, the hypothesis that there is a significant difference in the pattern of use of information and communication technology "Planning of learning" between the scores of students in the different cohorts is approved.

The results reveal that there is a significant relationship between some of the skills of scientific reasoning and some of the patterns of use of information and communication technology, coherently as it is contemplated by Prensky (2011) [8], the cognitive differences of the Digital Natives claim for new approaches in education, a better and more thoughtful "adjustment". This affirmation is made, since a relationship was found between the pattern of operations and computer concepts, and the thinking skills related to proportionality, correlational and probabilistic thinking and combinatorial thinking. Likewise, a relationship was found between the knowledge pattern of the internet and the skills of identification and control of variables, probabilistic thinking, correlational and probabilistic thinking.

In this way, when performing a correlation by cohort, according to the semester studied by the students in their training career, a significant relationship was found between some of the scientific reasoning skills and some of the patterns of use of information and communication technology. with students who are at the beginning, in the middle and at the end of their careers in a higher education institution of the Colombian Caribbean Coast. Similar result found by Benford, Russell; Lawson, Anton E. (2001) [9]. Relationships between Effective Inquiry Use and the Development of Scientific Reasoning Skills in College Biology Labs. National Science Foundation, Arlington, VA, in which the most important findings is that the ability to effectively use research in a university-level science lab It seems to be strongly associated with the formal and post-formal scientific reasoning skills of the instructor, and that the effective use of research promotes the acquisition of scientific reasoning skills in university-level students. To say, both the effective use of research and the use of ICT patterns facilitate the development of scientific reasoning skills in higher education students.

In that sense, it was found that the more students realize, whether early, mid or late in their careers, of the use of information and communication technologies, they will use more scientific reasoning skills. And in turn, while students use scientific reasoning skills, they will demonstrate patterns of use of information and communication technology. And precisely, Colombia, which in its history has not prevailed the provision of a clear policy for the use of information and communication technology [10], has led to the preparation of its inhabitants for the use of ICT is not the most appropriate and so has the use of information and communication technology, which does not facilitate the development of scientific reasoning skills, thus finding a significant relationship between scientific reasoning skills and the use that is made of it. makes of information technology and communication.

Likewise, it was found that, for the pattern of operations and computer concepts, there is a significant relationship for more scientific reasoning skills in students who are mid-career. Likewise, it was found that, for the pattern of Internet knowledge, there is a significant relationship for more scientific reasoning skills in students who are at the beginning of their careers. Likewise, it was found that, for the pattern of use of ICT in the planning of learning, there is a significant relationship for scientific reasoning skills, only in the mid-career students.

In turn, the Lawson Test allows students to be placed in three categories of reasoning: specific operations, transition operations and formal operations; In addition, it evaluates six aspects of scientific reasoning: a) conservation of physical magnitudes, b) proportional thinking, c) identification and control of variables, d) probabilistic thinking, e) correlational thinking and f) combinatory thinking [11].

In the same way, the categories of reasoning in which the students are located (specific operations, transition operations and formal operations), according to the results obtained with the Lawson Test, it was found that the predominant category is that of specific operations for all cohorts; However, the lowest value is presented to the students at the beginning of the career, followed by the value found for the students in the middle of the career and then the value found for the final-year students. It is observed with concern that the final year students do not show formal operations. It is highlighted that the mid-career students are those who show the most formal operations. Similar situation, found when applying Lawson's Test, to have a diagnosis of the degree of scientific reasoning of five groups of first-year students entering engineering degrees; and by applying a questionnaire on Force Concepts (Forcé Concept Inventory) to diagnose their level of conceptual knowledge in Mechanics, by Rodríguez, María D, Mena, Daniel A, Rubio, Carlos M. (2010) [11], in which the conclusion was obtained a significant percentage of students with a low level of scientific reasoning.

On the other hand, the students of the institution account for a medium or low level of scientific reasoning skills (medium level in conservation of physical magnitudes and low level in thought of proportionality, identification and control of variables, probabilistic thinking, correlational thinking and probabilistic and combinatory thinking). This is evidenced independently of the cohorts, that is, for the students at the beginning of their career, at the mid-career and at the end of their career, the medium or low level is presented for the same scientific reasoning skills.

Concerning the patterns of use of information and communication technology, it is concluded that the pattern of use of ICT in relation to learning planning [12] shows a high level; instead, both the Internet knowledge pattern and the overall ICT proficiency pattern have medium usage; On the other hand, the pattern of operations and computer concepts together with the pattern of research and management of digital information for learning present a low use. Ratifying as expressed by Garcia I, Gros B, Escofet A (2011) [13] in the XII International Congress of the Theory of Education, University of Barcelona: Profiles of use of technology and learning patterns among university students;

"Obviously, we can not assume that being a member of the" Internet generation "is synonymous with knowing how to use strategic technology-based tools to improve learning experiences in university environments."

With respect to the differences that exist between the different cohorts, it is concluded that the pattern of operations and computer science concepts gives an average level for the students of the beginning of the career, of a medium and low level (equally) in the students mid-career and a low level in the final-year students. It is evident that the level at which the patterns are presented: Internet knowledge, use of ICT in the planning of learning, research and management of digital information for learning and general tic competence; It is independent to the cohorts. This means that, for the students of career start, mid-career and final year, the high, medium or low level is presented for the same ICT use patterns. That is to say, it is observed that ICT usage patterns account for a better level achieved than scientific reasoning skills.

• Conclusion

No significant relationship was found between the pattern of research and management of digital information for learning and scientific reasoning skills. Likewise, it was found that, for probabilistic thinking ability, there is a significant relationship for more patterns of use of information and communication technology in students who are in the middle of their careers. Also, no significant relationship was found between the ability to conserve physical magnitudes and patterns of use of information and communication technology in students who are at the beginning of their careers. Likewise, no significant relationship was found between the abilities of: Proportionality thinking, probabilistic thinking and combinatory thinking; and patterns of use of information and communication technology in students who are at the end of their careers. In general terms, it is observed that the more students realize, at the beginning, in the middle or at the end of their careers, the use of information and communication technology, they will use more scientific reasoning skills. And in turn, while students use scientific reasoning skills, they will demonstrate patterns of use of information and communication technology.

Conflict of Interest

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The authors report there are no conflicts of interest.

References

[1] Villanueva, G., & De la Luz Casas, M. (2010).e-competencias: nuevas habilidades del estudiante en la era de la educación, la globalidad y la generación del conocimiento. Signo y pensamiento, XXIX, (56), 124-138.
[2] Bedoya, E., Behaine, B., Severiche, C., Marrugo, Y. y Castro, A. (2018). Redes de Conocimiento: Academia, Empresa y Estado. Revista Espacios, 39(8), Pág. 16.
[3] Vargas L, Villalba V, Severiche C, Bedoya E, Castro A and Cohen H 2019 TICs y gestión de la innovación en MiPyMEs: Un análisis con experimentos factoriales para las utilidades. *Espacios* **40** 24
[4] Flores, Ó., & De Arco, I. (2012). La influencia de las TIC en la interacción docente y discente en los procesos formativos universitarios. Revista de universidad y sociedad del conocimiento, 9(2), 31-47.
[5] Sobrino-Morrás, Á. (2011). Proceso de enseñanza aprendizaje y web 2.0: valoración del conectivismo como teoría de aprendizaje post-constructivista. Estudios sobre educación, 20, 117-140.
[6] MinTIC (2017). MinTIC revela los primeros resultados del Observatorio de Economía Digital. Recuperado el 13 de noviembre de 2018, de https://www.mintic.gov.co/portal/604/w3-article-61929.html
[7] Hernández, R; Fernández, C; Baptista, P. (2014). Metodología de la Investigación. México: Mc Graw Hill.
[8] Prensky M (2011). Nativos e inmigrantes digitales. Madrid, España: SEK.
[9] Lawson A.E, Clark E, Cramer-Meldrum K.A, Falconer J.M, Sequist Y, Kwon (2000). "Development of scientific reasoning in college biology: Do two levels of general hypothesis-testing skills exist?". J. Res. Sci. Teach. 37, 81-101.
[10] MinTIC (2008). Plan Nacional de Tecnologías de la Información y las Comunicaciones. Recuperado el 21 de julio de 2016, de http://bit.ly/29Z8QNr
[11] Rodríguez M, Mena D, Rubio C (2010). Razonamiento científico y conocimientos conceptuales de mecánica: un diagnóstico de alumnos de primer ingreso a licenciaturas en ingeniería. Formación Universitaria, 3 (5), 37-46.
[12] Castro S, Guzmán B, Casado D. Las TIC en los procesos de enseñanza y aprendizaje
Laurus . 2007 13 (23): 213-234.
[13] Marulanda, Carlos E, Giraldo, Jaime, & López, Marcelo. (2014). Acceso y uso de las Tecnologías de la información y las Comunicaciones (TICs) en el aprendizaje: El Caso de los Jóvenes Preuniversitarios en Caldas, Colombia. Formación universitaria, 7(4), 47-56.

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