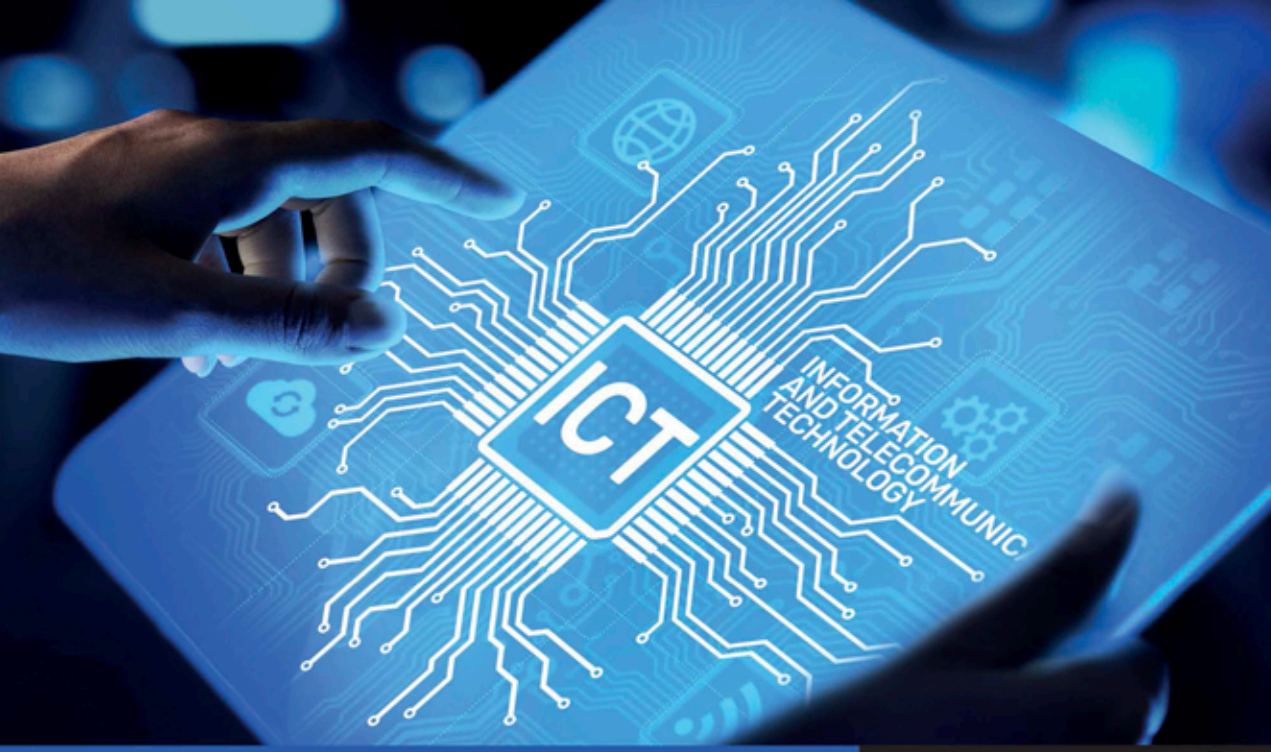

Serie *Investigación*

IMPORTANCE OF ICT IN THE TEACHING-LEARNING PROCESS:
MIDDLE AND HIGHER EDUCATION STUDIES

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IMPORTANCE OF ICT IN THE TEACHING-LEARNING PROCESS:

MIDDLE AND HIGHER EDUCATION STUDIES

The integration of ICT in education entails several challenges: the first, to diagnose, at a global level, how this process is being carried out in different educational fields. Likewise, another challenge is to analyze what has really been the impact that this integration has had on improving educational quality in Colombia. It is assumed that ICT applied to education generates successful paths to promote both teaching and learning. However, it is necessary to enter the fields of education to corroborate if the previous statement is valid. A third challenge would be to analyze the effect of ICT on the efficiency of educational institutions. In this sense, it is not only necessary to determine the ICT integration process, but also to determine how the same institutions assume responsibility for the digital transformation of education. Another challenge is to validate, experiences carried out using ICT to improve learning processes. Finally, another of the challenges that can be highlighted, and is the most relevant, is the need to assume an ethical stance regarding the management of ICT in education. This book covers each of the challenges with the aim of promoting the processes of innovation and digital transformation of education from a scientific, critical, and above all, ethical perspective.

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Index

Introduction

The 4.0 revolution brings along with its significant challenges. One of them is to face the process of integrating ICTs in different fields. One of them, and perhaps the most important, is education. The speed with which the world changes overwhelms us. However, the feeling that these changes cause should not worry us but rather awaken our stupefaction, which can be used as an initial pushing force to understand what surrounds us.

The Sergio Arboleda University has decided to meet the challenge of articulating the advantages of digital civilization informal education developments, without disregarding the critical and scientific nature that characterizes the academy. This book is the result of the above. In it, the reader will be able to recognize how ICTs impact the improvement of learning outcomes in different fields.

For example, in the first chapter, the current situation regarding research on the process of integrating ICTs in teaching and learning processes is carefully analyzed. In the results, I allow myself to tell the reader that assumptions of ICTs in education are not entirely correct: the improvement of teaching depends not only on the medium but also on the person who uses it.

The second chapter presents an investigation carried out by Sergio Arboleda University in the department of Cundinamarca. The objective was to evidence if the integration of ICTs has any influence on the standardized educational tests in Colombia called Saber 11. This study was carried out in a research alliance with the Colombian Institute for the Evaluation of Education (ICFES[1]).

[1] Instituto Colombiano para la Evaluación de la Educación

How efficient are the schools in Bogotá and Cundinamarca? This is the question we sought to answer in the third chapter based on data analysis. The study reveals how some schools do not use ICTs properly, which affects their performance indicators.

Another query addressed in this book revolves around the way ICTs are used. Although there are statistical models that describe the process of integrating ICTs in education, the question of "how" exceeds mathematical limits and instead delves into a qualitative interpretation. In the fourth chapter, the reader will find an ethnographic analysis that allowed understanding the integration and its impact on academic performance tests.

Chapters 2, 3, and 4 use Colombia as a reference and as the study's context. Nevertheless, the Sergio Arboleda University considers internationalization to be an institutional pillar. For this reason, thanks to an inter-institutional agreement with the Andrés Bello University in Venezuela, the editors of this book were international teachers from the Ph.D. course in ICT innovation in the classroom and its impacts on education. Thanks to this knowledge exchange, Ph.D. students Henry Martínez, Gloria Tarrío, and Claudia Salazar present their findings regarding the impact of the use of educational software in education (chapter 5) and the integration of ICTs in reading and writing teaching processes (chapter 6). Our University also assumes the responsibility of creating spaces dedicated to training and research so that, based on international cooperation, the necessary epistemological framework is built to integrate ICTs appropriately.

Finally, the authors reflect on the ethics of educational technology. Since its foundation, our University has been highly concerned with offering a humanistic education, for we cannot assume that the growth of technology will imply the loss of the development and strengthening of the human condition. Our formula to face the force of digital civilization is more humanism and more technology. For this reason, and as a closing statement, the last chapter presents the foundation of every practice of man: ethics. For us, it is the most necessary and the most important: to form human beings, above all.

We thank the reader for the opportunity to show them, in part, our advances in research around the integration of ICTs in the teaching and learning processes. We will continue working to provide, from the academy, all the necessary support to consolidate a more humane and more integral civilization. Our eyes fixed upon the world 4.0.

Dr. Rodrigo Noguera Calderón
Rector
Sergio Arboleda University

Chapter 1

The TPACK model as an analysis perspective in the integration of ICTs in education: a state of the art

Sergio Alejandro Rodríguez Jerez[1]

Abstract

The process of integrating ICTs in education is a phenomenon that has been relatively studied in recent decades. Nevertheless, throughout the last five years, due to the dynamics of what is now called the digital age, the concern to improve education using new technologies has increased. This chapter aims to analyze the most relevant publications on this matter to describe the status quo. The TPACK model is used as an analysis perspective due to its high relevance in integrating ICTs in education. Likewise, the descriptive methodology uses the interpretation levels proposed by Rodríguez Jerez (2019) to carry out a hermeneutic analysis. The results obtained are organized from the area, and the units of convergence are found. The conclusions provide a framework to reflect and understand the current process of integrating ICTs in teaching and learning.

Keywords

ICTs, education, TPACK model

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Introduction

In 1937, Ortega & Gasset (1982) outlined, for one of the first times, the need to study technique as a co-substantial element of humanity: technique emerges from the need to take over the environment and transform matter, through methods, procedures, and tools for the benefit of man. For both Ortega and Heidegger (1997), humankind becomes more human due to technique. The possibility of transforming the environment is prevalent in the construction of societies. However, every action that comes from man is full of intention.

The industrial revolution highlighted the supremacy of technique, which world wars later ratified. Technology thus arises as a field of an in-depth study of technique and humanity surrenders, almost wholly, to a race in favor of appropriating the most efficient methods to solve the problems that surround us, which is why the fourth industrial revolution assumed technology as the designating element of new societies (Vinck, 2018). Now, life cannot be contemplated without technology. As UNESCO's director, Irina Bokova, points out: this is not a digital revolution, but a digital civilization (Vinck, 2018, p. 13). Consequently, on the one hand, we have technology as a reference for human development and, on the other, the use of technology-based on the intention of each subject. Technique and use are the aspects to consider no longer in the meditation of technique but the meditation of technology. In other words, the thoughts of Ortega and Heidegger must now delve into a new and broader spectrum than the one envisioned in the twentieth century.

The current technological development is overwhelming. The transition from the first to the second industrial revolution lasted more than 100 years, while it only lasted 20 from the third to the fourth. The speed of technological development is exponential, so some people infer that the fifth revolution is about to happen (Maxwell, 2014).

Considering this, ICTs have become a benchmark for study in multiple fields, and education is no exception. Since 1991, for example, the need to incorporate ICTs in education has been a preponderant concern for the Colombian State. With Law 115 of 1994 and with the appearance of the

General Systems of Accreditation of Education[2] in Colombia, the need to immediately improve the educational quality indexes of the country is recognized.

In this sense, and thanks to the technological and communicative development of recent times, the Ministry of National Education (MEN[3]) has designed a series of ICT integration policies in education systems. The Live Digital Plan[4] 2014-2018 demonstrates the above and reveals the urgency of using ICTs as tools for the improvement of education.

However, this current urgency of incorporating ICTs in classrooms requires meditation, a moment of reflection in which the scope, limitations, and phenomena of both complimentary and malicious use of technology are put on the scale. Also, meditation or reflection involves an analysis perspective. For example, Mishra & Koehler (2006) explained the TPACK model to analyze the process of integrating ICTs within the framework of pedagogical practice. The TPACK model does not correspond to a created model, but to the study of the factors that are always present in integrating ICTs in education. Therefore, this model serves as the analysis perspective to study any training process from the world of teacher knowledge.

> The TPACK refers to the knowledge that a teacher has on coordinating the use of specific activities of the subjects or activities on specific topics, doing so with representations on certain topics, using ICTs to facilitate student learning. As the technologies used in these activities and representations become ubiquitous, the TPACK becomes PCK. In short, it refers to the didactic knowledge of the content to the knowledge required by teachers to integrate technology in their teaching in any content area (Cabero, Marín, & Castaño, 2015).

The TPACK model then becomes the immediate reference to analyze the integration of ICTs in teaching processes. The TPACK model has been used as an analytical perspective for improving pedagogical processes in all academic fields, from essential to university education, as suggested by

[2] Sistemas Generales de Acreditación de la Educación

[3] Ministerio de Educación Nacional

[4] Plan Vive Digital

the consulted bibliography. The use and impact of the referred model first spread in the United States. Mishra & Koehler (2006) were responsible for popularizing it and making it accessible to different pedagogical spheres not only in North America, but also in Europe, Asia, and Australia, as it began to be part of proposals by authors such as Jimoyiannis (2010) in Greece, Jamieson-Proctor, Finger & Albion (2010) in Australia, and Jang & Tsai (2012) in China.

It seems that the inclusion of the TPACK model in the different academic scenarios around the world and the extraordinary results it has shown in the face of the evolution of pedagogy and the new ways of teaching that technology offers has a direct impact on what and how the students of this century learn. Thus, it can be assumed that the use of technological tools allows the knowledge imparted in the classroom to be more quickly and efficiently assimilated. However, it would be worth corroborating the above with a study that documented and analyzed the high-impact researches from the last five years that have tried to evaluate, using the TPACK model as a reference framework, the process of ICT integration in the world. It can be therefore deduced that the question to be answered is: What has been the status quo, during the last five years, of scientific publications regarding the integration of ICTs in education through the TPACK model as an analysis perspective?

The following general objective must be fulfilled:

Describe the current situation of high-impact scientific publications that refer to the process of integrating ICTs in education, based on the reference framework of the TPACK model.

Similarly, to achieve the general objective, the following specific objectives are established:

Document the scientific research related to the integration of ICTs in education in the last five years.

Discriminate, using a scientometric analysis, the most relevant publications from the last five years regarding integrating ICTs in education using the TPACK model.

Analyze high-impact scientific production of the last five years about integrating ICTs in education using the TPACK model, through a chronological and geographical study.

Methodology

The present study is a descriptive analysis of the high-impact scientific publications from the last five years that have studied the integration of ICTs in education, based on the referential framework proposed by the TPACK model. The research was divided into five phases:

The first phase consisted of carrying out an integrated search of all the publications referring to the proposed topic, taking as a primary unit of analysis of the last five years' chronological delimitation. The academic database integration tool offered by EBSCO was used with the following search criteria equation:

$$Filter\ 1\colon \forall(U\colon publications \rightarrow (ICT \cup TIC \cup Information_{Tech}))$$
$$Filter\ 2\colon \forall(Filter1\colon publications \rightarrow (education\ \cap Tpack))$$
$$Filter\ 3\colon \forall(filter\ 2\colon publications \rightarrow (year2015\ \cap year\ 2016\ \cap year\ 2017 \cap year\ 2017\ \cap year\ 2018\ \cap year\ 2019))$$
$$Filter\ 4\colon \forall(filter\ 3\ publications\ \rightarrow\ education)$$

After this first gathering of information, the researches that expressly referred to the process of ICT integration using the TPACK model were outlined with a standard state of the art matrix in which, based on the data offered by each of the publications recovered in the first phase, those that used the TPACK model as an analysis perspective of qualification were qualitatively refined.

In the third phase, the 704 profiled publications with the established criteria underwent a scientometric impact factor analysis to determine how many of them could be classified as high impact. The following criteria established this indicator:

a. Number of indexed citations
b. Resource usage percentage (full resource views, resource summary view resource hyperlink number, resource link in social networks)

c Resource capture percentage (number of downloads, number of readers)

The scientometrics used was mediated by Plum Analytics metrics, which allowed for greater fidelity of the high-impact criteria.

In the fourth phase, a hermeneutical analysis of speech saturation and contrast was carried out to cross-examine the information obtained descriptively. A fundamental statistic was made from the purification carried out in the previous phase, which allowed to delimit the number of articles, used as an analysis corpus, to 53 in total. Taking as reference the year and the area of publication, the respective crossing of information was made to determine the convergences and divergences found in the information contained in each of the publications. The methodology followed in this hermeneutic saturation and contrast analysis corresponds to the proposal of Rodríguez Jerez (2019), precisely the technique presented by the author to determine the interpretative levels of a text.

In the last phase, the information was compiled, and the results were presented.

Results

According to the established search criteria, of the 704 publications found from the last five years, only 53 are of high impact and its descriptive analysis are showed in tables 1.1 and 1.2.

Tabla 1.1
Total description of high-impact publications by area

DESCRIPTION BY AREA	COUNT
EUROPE	28
ASIA	10
NORTH AMERICA - CANADA	8
OCEANIA	4
AFRICA	2
LATIN AMERICA	1
Total	**53**

Nota: most of the high-impact publications are concentrated in Europe, especially in the Nordic area of the continent.

Table 1.2
Total description of high-impact publications in the European area

Row tags	Count Europe
GERMANY	1
BELGIUM	1
SPAIN	9
ESTONIA	1
FINLAND	2
HOLLAND	4
LITHUANIA	1
NORWAY	6
UNITED KINGDOM	1
SWEDEN	1
SWITZERLAND	1
Total	**28**

Note: countries such as Norway, Finland, Estonia, Lithuania are represented in the given sample.

This poses a series of qualitative reflections from the hermeneutical analysis of these corpora in particular. In Norway, for example, the researchers found focus on three dimensions: a. ICT impact on academic performance; b. ICT impact on the improvement of teaching practice; C. TPACK model as an analysis tool to measure the integration of ICTs in education.

It is necessary to emphasize that, in quantitative studies such as Scherer, Rohatgi & Hatlevik's (2017), the results evidence that the integration of ICTs does not significantly affect academic performance. Nevertheless, as a positive effect, the study by Scherer, Tondeur, Siddiq & Baran (2018) points out that the integration of ICTs, using the TPACK model as a reference for the analysis, improves the attitude of both the teacher and the student regarding the new demands of digital civilization.

The second dimension refers to the impact of ICTs in pedagogical practice. Quantitative studies, such as Tømte, Enochsson, Buskqvist &

Kårstein (2015), have similar results: It cannot be demonstrated that ICTs improve the teaching process directly. However, qualitative studies such as Xiang Ying Mei, Endre Aas, & Magnhild Medgard (2019) point out otherwise. In this case, the contradiction is engaging. The first possible hypothesis is that there seems to be a social imaginary around the advantages of ICTs in education. This imaginary, whether due to the lack of an objective measurement model, has not been proven in a real scenario or, on the contrary, shows that this vision draws away from how ICTs affect educational environments. As a result of a study of interpretative convergences, it can be noticed that high-impact researches from Germany, Finland, Lithuania, Sweden, Switzerland, and Estonia has the following elements in common: a. improvement of pedagogical practice through ICTs; b. TPACK model as an analysis tool to evaluate the integration of ICTs in the classroom; C. student perception of ICT-mediated education; d. ICTs as elements that allow human development.

Concerning the first element referred to, the studies by Spante, Karlsen, Nortvig, & Christiansen (2014) and Taimalu & Luik (2019) indicate that the impact of ICTs on teaching processes is positive but in the domain of technological knowledge. According to the TPACK model, the technological domain is only one of the references in integrating ICTs in education. Thus, it can be inferred that the practice does not improve, although it does provide conditions and possibilities to be more effective. Similarly, apropos of the second element, the studies by Valtonen et al. (2017) and Lachner, Backfisch & Stürmer (2019), argue that it is necessary to create more reliable measuring instruments to determine the integration of technologies through the TPACK model. This implies thinking that there may be a bias, to some extent, from a quantitative point of view in determining the incidence of ICTs in teaching processes.

Regarding the third element, Sointu et al. (2019) conduct a study with more than 317 students from Finland and conclude that incorporating the TPACK model in secondary education helps improve the favorable perception of students of their teachers. This finding is especially interesting since technology can be seen as an element of willingness to learn more than to improve learning. Finally, it is suggestive how in the Nordic countries, in addition to the concern of analyzing the integration of ICTs in education

as a necessary element to improve educational quality, there is a concern for applying ICTs as an articulating axis of national development, as can be seen in the studies carried out by Yildiz (2016) and Petko, Egger, Cantieni & Wespi (2015).

After reviewing the Nordic area, the same process of convergence and divergence analysis was carried out in Belgium, Spain, Holland, and the United Kingdom. Consequently, the following convergent elements were found: a. the TPACK model to analyze the process of integration of ICTs in education; b. ICTs as an indicator of impact on the improvement of pedagogical practices; c. integrating ICTs in teaching practice.

Faced with the first convergence, the studies by Bueno-Alastuey, Villarreal & García Esteban (2018) and Cubeles & Riu (2018) refer to the effectiveness of the TPACK model to determine, on the one hand, how the digital competence of higher education teachers can be evaluated with this analysis perspective and, on the other hand, how this same framework can be used to analyze specific elements of the digital practices of teaching such as telecollaboration. The studies above are quantitative. The samples used are case studies, so it cannot be inferred that they are representative referents of a specific population.

Concerning the second element, the research carried out by Almerich, Orellana, Suárez-Rodríguez & Díaz-García (2016) reveals how digital competencies positively affect pedagogical competencies with a sample of 1,095 primary schools, secondary and higher-level teachers of the Valencian community in Spain. It was proved that the management of ICTs improves teaching competencies in the different levels of training.

The third element of this unit of analysis refers to the process of ICTs integration with teaching mechanisms. The studies developed by Kosnik et al. (2016), Tondeur, Scherer, Siddiq & Baran (2017), Haydn (2014), Gutiérrez Porlán (2014), Moreira-Fontán, García-Señorán, Conde-Rodríguez & González, (2019), Sánchez-Prieto, Hernández-García, García-Peñalvo, Chaparro-Peláez & Olmos-Migueláñez (2019), Uerz, Volman & Kral (2018) present various explanatory models for this integration, depending on the specific context of each one. However, it is interesting to find that

the integration process is tricky in technological knowledge and more than ICT infrastructure that is not effective and efficient for specific teaching demands. Consequently, the term digital self-efficacy becomes a necessary element in appropriating ICTs for teaching with quality standards. The study carried out by Tondeur, Aesaert, Prestridge & Consuegra (2018) in Belgium stands out: through an empirical study, the authors demonstrated how gender and age variables are not relevant in the processes of ICT integration in education.

After analyzing the European area, the Asian area's high-impact publications will be reviewed in table 1.3.

Table 1.3
Total description of high-impact publications in the Asian area

COUNTRY	AREA Count
CHINA	5
SOUTH KOREA	1
TAIWAN	3
TURKEY	1
Total	**10**

Note: high-impact publications are in China.

In the hermeneutical analysis carried out in this country's publications, the following convergent elements are identified: a. ICTs as an aspect that improves teaching practice; b. ICTs as an aspect that improves the quality of education.

The studies of Wu, Hu, Gu & Lim (2016), Xiong & Lim (2015), and Mei (2019) expose the advantages of digital awareness over teacher performance. For example, Xiong & Lim (2015) carried out a research that took into account two teacher training programs in higher education and showed, using a sample of 99 people, to understand the need to integrate ICTs in teaching practice is related to curriculum leadership. In other words, the research indicated that several people who have a leading role in the processes of systematization of education are aware of the new challenges demanded by the digital era. On the other hand, and about the second

element mentioned above, ICTs in China's high-impact research that uses the TPACK model as an analysis perspective has no impact on student performance. The quantitative studies carried out by Wang, Tigelaar & Admiraal (2019) and Li, Sun & Jee (2019) show that, as demonstrated by Li, Sun & Lee (2019), they affect, for example, the quality of the learning acquired by the students in the particular case of a second language.

The convergent elements identified in South Korea, Taiwan, and Turkey are a. TPACK as a benchmark for analysis in the ICT integration process; b. the impact of ICTs in improving teaching practice. For Akyuz (2018), Chuang, Weng & Huang (2015), and Tseng, Cheng & Yeh (2019), the TPACK model must be redefined from the context in which it is used. According to its quantitative research results, the reference model does not cover the entire framework of integration possibilities. Secondly, Hsu (2017) and Joo, Lim & Kim (2016) ratify what has been found in other areas: ICTs do not directly affect the improvement of teaching practice, but they help to be more aware of the importance of technology. In other words, ICTs allow improving the attitudinal component of teachers considering the demands of the present time.

After analyzing the Asian area, the area between North America and Canada will be reviewed in table 1.4.

Table 1.4.
Total description of high-impact publications in the North American area

NORTH AMERICA - CANADA	Count
CANADA	2
UNITED STATES	6
Total	**8**

The North American area investigations converge in the following elements: a. the TPACK model as an instrument of analysis in the integration of ICTs in education; b. ICT impact on teaching practice; C. ICT integration models in education. About the first element, the author's Stockless, Villeneuve & Gingras (2018), Lefebvre Sonia (2014),

and Nelson, Voithofer & Cheng (2019) state that the TPACK model allows the understanding of the integration of ICTs in the classroom from the didactic point of view. However, Cheng & Xie (2018) point out in a quantitative study carried out with a sample of 109 professors from the United States that the TPACK model only effectively measures the belief system.

Regarding the impact of ICTs on teaching, the studies by McCulloch, Hollebrands, Lee, Harrison & Mutlu (2018) and Blackwell, Lauricella & Wartella (2016) conclude that ICTs, by themselves, do not have an impact on the improvement of teaching practices. The integration of ICTs improves the attitudinal and motivational components; some of the values are required to develop a quality training experience. For this reason, the researchers mentioned above emphasize the importance of advancing in the understanding of the development of digital competence in teachers.

In the case of Oceania, the only country that has produced high-impact research in Australia. Of the four investigations found, two of them present a state of the art to analyze the integration of ICTs in education (Lai & Bower, 2019; Pretto & Curró, 2017). The other two show how the TPACK model offers excellent advantages to analyze the integration of ICTs in teaching and learning processes (Gill & Dalgarno, 2017; Reyes, Reading, Doyle & Gregory, 2017).

In Africa, two high-impact research types were found: one in Tanzania and one in the Cape Peninsula (Chigona, 2015; Kihoza, Zlotnikova, Bada & Kalegele, 2016). Both cases demonstrated how the TPACK model was a useful reference for analyzing the process of integrating ICTs in education. It is striking that the study presented by Kihoza et al. (2016) combines the TPACK with the SAMR model: the research suggests that the integration of an explanatory model such as the TPACK with a methodological model such as the SAMR offers a much better glimpse of the integration process mentioned above.

In Latin America, the only high-impact material found was Agustín Flores' (2018). In this research, the TPACK model was used to explain the National University of the Northeast's technological pedagogical content

knowledge in Argentina. It shows that, in this particular case, the TPACK model is a useful tool for evaluating and explaining the process of integrating ICTs in education.

Conclusions

The synthesis of the results obtained allows deducing that the TPACK model will not reveal ICT integration's complexity in the teaching and learning processes. Any study that attempts to analyze the referred integration process must use another additional mechanism, qualitative methodologies, more profound descriptive methods, or complex data analysis methods to comprise this complex phenomenon.

It is also interesting to perceive how ICTs begin to become a part of human development plans' daily discourse. This leads us to think that there can be several imaginaries regarding the advantages offered by ICTs in different areas. For this reason, fundamentally, it is necessary to meditate and reflect on technology, and that way, clear the air from propaganda and the immediacy of the world.

However, it is almost definitive that the TPACK model does allow analyzing the belief system and the level of awareness of teachers about the need to integrate ICTs in teaching processes. Nevertheless, it is pertinent to clarify that the TPACK model is a theoretical and non-operational "framework." The proposal by Kihoza et al. (2016) to integrate an operating model as SAMR is thus of interest. This model incorporates metacognitive procedures to create the ability to handle teaching technologies (Jude, Kajura & Birevu, 2014; López-García, 2015; Tsybulsky & Levin, 2016).

If knowledge and technology management is considered a skill of 21st-century teachers, there must be a theoretical and operational reference framework for teachers' 21st-century digital skills. As set out in the various training frameworks, competencies must integrate the attitudinal, epistemological, praxeological, and ethical components that teaching entails, considering the new digital civilization (Almerich et al., 2016; Punie, 2007; Sampson & Fytros, 2008). Perhaps this is the course that must be followed to improve the training spaces in the world.

Finally, the concept of digital self-efficacy is an essential reference to continue researching and carrying out actions in pedagogical and didactic environments. Teaching quality is becoming more complicated due to the saturation of persistent information in the knowledge society. The objective is to create paths to understand society's problems and establish improvement strategies with the advantages offered by the 4.0 world.

For future research with the same main objective as this study, it is recommended to have a more significant sample that considers the impact factor and the established period. It is very likely that, due to the current scientific publication and dissemination processes, the investigations that are working on the subject referred to have not been visualized in the tools used. Likewise, it is advised that the analysis of the literature use defined interpretation techniques to reduce, to some extent, the natural biases that occur when the information is analyzed qualitatively.

References

Akyuz, D. (2018). Measuring technological pedagogical content knowledge (TPACK) through performance assessment. *Computers and Education*, *125*, 212–225. doi: 10.1016/j.compedu.2018.06.012

Almerich, G., Orellana, N., Suárez-Rodríguez, J., & Díaz-García, I. (2016). Teachers' information and communication technology competences: A structural approach. *Computers and Education*, *100*, 110–125. doi: 10.1016/j.compedu.2016.05.002

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2016). The influence of TPACK contextual factors on early childhood educators' tablet computer use. *Computers and Education*, *98*, 57–69. doi: 10.1016/j.compedu.2016.02.010

Bueno-Alastuey, M. C., Villarreal, I., & García-Esteban, S. (2018). Can telecollaboration contribute to the TPACK development of pre-service teachers? *Technology, Pedagogy and Education*, *27*(3), 367–380. doi: 10.1080/1475939X.2018.1471000

Cabero, J., Marín, V., & Castaño, C. (2015). Validation of the application of TPACK framework to train teacher in the use of ICT. *@tic. Revista d'innovació Educativa*, *0*(14), 13–22. doi: 10.7203/attic.14.4001

Cheng, S. L., & Xie, K. (2018). The relations among teacher value beliefs, personal characteristics, and TPACK in intervention and non-intervention settings. *Teaching and Teacher Education*, *74*, 98–113. doi: 10.1016/j.tate.2018.04.014

Chigona, A. (2015). Pedagogical shift in the twenty-first century: preparing teachers to teach with new technologies. *Africa Education Review*, *12*(3), 478–492. doi: 10.1080/18146627.2015.1110912

Chuang, H.-H., Weng, C.-Y., & Huang, F.-C. (2015). A structure equation model among factors of teachers' technology integration practice and their TPCK. *Computers & Education*, *86*, 182–191. doi: 10.1016/j.compedu.2015.03.016

Cubeles, A., & Riu, D. (2018). The effective integration of ICTs in universities: the role of knowledge and academic experience of professors. *Technology, Pedagogy and Education*, *27*(3), 339–349. doi: 10.1080/1475939X.2018.1457978

Flores, A. (2018). Didactic conceptions and use of ICT in the university education of degree. Multi-case study and TPACK analysis framework. *Praxis Educativa*, *22*(1), 64–72. doi: 10.19137/praxiseducativa-2018-220106

Gill, L., & Dalgarno, B. (2017). A qualitative analysis of pre-service primary school teachers' TPACK development over the four years of their teacher preparation programme. *Technology, Pedagogy and Education*, *26*(4), 439–456. doi: 10.1080/1475939X.2017.1287124

Gutiérrez, I. (2014). Perfil del profesor universitario español en torno a las competencias en tecnologías de la información y la comunicación. *Pixel-Bit Revista de Medios y Educación*, 51–65. doi: *10.12795/pixelbit.2014.i44.04*

Haydn, T. (2014). How do you get pre-service teachers to become 'good at ICT' in their subject teaching? The views of expert practitioners. *Technology, Pedagogy and Education*, *23*(4), 455–469. doi: 10.1080/1475939X.2014.892898

Heidegger, M. (1997). La pregunta por la técnica. In *Filosofía, Ciencia y Técnica*.

Hsu, S. (2017). Developing and validating a scale for measuring changes in teachers' ICT integration proficiency over time. *Computers and Education*, *111*, 18–30. doi: 10.1016/j.compedu.2017.04.001

Jamieson-Proctor, R., Finger, G., & Albion, P. R. (2010). Auditing the TPACK Capabilities of Final Year Teacher Education Students: Are they ready for

the 21st century? In *Digital Diversity: Australian Computers in Education Conference 2010*.

Jang, S. J., & Tsai, M. F. (2012). Exploring the TPACK of Taiwanese elementary mathematics and science teachers with respect to use of interactive whiteboards. *Computers and Education*. doi: 10.1016/j.compedu.2012.02.003

Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers professional development. *Computers and Education*. doi: 10.1016/j.compedu.2010.05.022

Joo, Y. J., Lim, K. Y., & Kim, N. H. (2016). The effects of secondary teachers' technostress on the intention to use technology in South Korea. *Computers and Education*, *95*, 114–122. doi: 10.1016/j.compedu.2015.12.004

Jude, L., Kajura, M., & Birevu, M. (2014). Adoption of the SAMR Model to Asses ICT Pedagogical Adoption: A Case of Makerere University. *International Journal of E-Education, e-Business, e-Management and e-Learning*, *4*(2). doi: 10.7763/ijeeee.2014.v4.312

Kihoza, P., Zlotnikova, I., Bada, J., & Kalegele, K. (2016). Classroom ICT integration in Tanzania: Opportunities and challenges from the perspectives of TPACK and SAMR models. *International Journal of Education and Development Using Information and Communication Technology*, *12*(1), 107–128.

Kosnik, C., White, S., Beck, C., Marshall, B., Lin Goodwin, A., & Murray, J. (2016). *Building bridges: Rethinking Literacy Teacher Education in a Digital Era*. doi: 10.1163/9789463004916

Lachner, A., Backfisch, I., & Stürmer, K. (2019). A test-based approach of Modeling and Measuring Technological Pedagogical Knowledge. *Computers & Education*, *142*, 103645. doi: 10.1016/j.compedu.2019.103645

Lai, J. W. M., & Bower, M. (2019). How is the use of technology in education evaluated? A systematic review. *Computers and Education*, *133*, 27–42. doi: 10.1016/j.compedu.2019.01.010

Lefebvre Sonia, P. D. (2014). Intégration des technologies de l'information et de la communication: types de connaissances abordées dans le discours d'enseignants en exercice et d'étudiants en formation initiale. *Canadian Journal of Education / Revue Canadienne de l'éducation*, *37*(3),

1. Retreieved September 26, 2019 from http//pdfs.semanticscholar.org/1105/21303871ff44627a121d8e2715a6468d409b.pdf

Li, G., Sun, Z., & Jee, Y. (2019). The more technology the better? A comparison of teacher-student interaction in high and low technology use elementary EFL classrooms in China. *System*, *84*, 24–40. doi: 10.1016/j.system.2019.05.003

López-García, J.-C. (2015). SAMR, modelo para integrar las TIC en procesos educativos. Retreieved from: http//Eduteka.Icesi.Edu.Co/Articulos/Samr website: http://eduteka.icesi.edu.co/articulos/samr

Maxwell, I. A. (2014). The fifth industrial revolution. *Chemistry in Australia*, p. 38.

McCulloch, A. W., Hollebrands, K., Lee, H., Harrison, T., & Mutlu, A. (2018). Factors that influence secondary mathematics teachers' integration of technology in mathematics lessons. *Computers and Education*, *123*, 26–40. doi: 10.1016/j.compedu.2018.04.008

Mei, B. (2019). Preparing preservice EFL teachers for CALL normalisation: A technology acceptance perspective. *System*, *83*, 13–24. doi: 10.1016/j.system.2019.02.011

Mei, X. Y., Aas, E., & Medgard, M. (2019). Teachers' use of digital learning tool for teaching in higher education: Exploring teaching practice and sharing culture. *Journal of Applied Research in Higher Education*, *11*(3), 522–537. doi: 10.1108/JARHE-10-2018-0202

Mishra, P., & Koehler, M. J. (2006a). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*. doi: 10.1111/j.1467-9620.2006.00684.x

Moreira-Fontán, E., García-Señorán, M., Conde-Rodríguez, Á., & González, A. (2019). Teachers' ICT-related self-efficacy, job resources, and positive emotions: Their structural relations with autonomous motivation and work engagement. *Computers and Education*, *134*, 63–77. doi: 10.1016/j.compedu.2019.02.007

Nelson, M. J., Voithofer, R., & Cheng, S. L. (2019). Mediating factors that influence the technology integration practices of teacher educators. *Computers and Education*, *128*, 330–344. doi: 10.1016/j.compedu.2018.09.023

Ortega & Gasset, J. (1982). Meditación de la técnica y otros ensayos sobre ciencia y filosofía. In *Obras de José Ortega & Gasset*. Madrid, España: Revista de Occidente/ Alianza Editorial.

Petko, D., Egger, N., Cantieni, A., & Wespi, B. (2015). Digital media adoption in schools: Bottom-up, top-down, complementary or optional? *Computers and Education*, *84*, 49–61. doi: 10.1016/j.compedu.2014.12.019

Pretto, G., & Curró, G. (2017). An Approach for Doctoral Students Conducting Context-Specific Review of Literature in IT, ICT, and Educational Technology. *New Review of Academic Librarianship*, *23*(1), 60–83. doi: 10.1080/13614533.2016.1227861

Punie, Y. (2007). Learning spaces: An ICT-enabled model of future learning in the Knowledge-based Society. *European Journal of Education*, *42*(2), 185–199. doi: 10.1111/j.1465-3435.2007.00302.x

Reyes, V. C., Reading, C., Doyle, H., & Gregory, S. (2017). Integrating ICT into teacher education programs from a TPACK perspective: Exploring perceptions of university lecturers. *Computers and Education*, *115*, 1–19. doi: 10.1016/j.compedu.2017.07.009

Rodríguez Jerez, S. A. (2019). Aproximaciones de una metodología semiótica para el análisis de la educación en Colombia: un aporte al desarrollo de la edusemiótica. *PRACS: Revista Eletrônica de Humanidades Do Curso de Ciências Sociais Da UNIFAP*, *11*(2), 117. doi: 10.18468/pracs.2018v11n2.p117-126

Sampson, D., & Fytros, D. (2008). Competence Models in Technology-Enhanced Competence-Based Learning. In *Handbook on Information Technologies for Education and Training* (pp. 155–177). doi: 10.1007/978-3-540-74155-8_9

Sánchez-Prieto, J. C., Hernández-García, Á., García-Peñalvo, F. J., Chaparro-Peláez, J., & Olmos-Migueláñez, S. (2019). Break the walls! Second-Order barriers and the acceptance of mLearning by first-year pre-service teachers. *Computers in Human Behavior*, *95*, 158–167. doi: 10.1016/j.chb.2019.01.019

Scherer, R., Rohatgi, A., & Hatlevik, O. E. (2017). Students' profiles of ICT use: Identification, determinants, and relations to achievement in a computer and information literacy test. *Computers in Human Behavior*, *70*, 486–499. doi: 10.1016/j.chb.2017.01.034

Scherer, R., Tondeur, J., & Siddiq, F. (2017). On the quest for validity: Testing the factor structure and measurement invariance of the technology-dimensions in

the Technological, Pedagogical, and Content Knowledge (TPACK) model. *Computers and Education*, *112*, 1–17. doi: 10.1016/j.compedu.2017.04.012

Scherer, R., Tondeur, J., Siddiq, F., & Baran, E. (2018). The importance of attitudes toward technology for pre-service teachers' technological, pedagogical, and content knowledge: Comparing structural equation modeling approaches. *Computers in Human Behavior*, *80*, 67–80. doi: 10.1016/j.chb.2017.11.003

Sointu, E., Valtonen, T., Hirsto, L., Kankaanpaa, Jenni Saarelainen, M., Makitalo, K., Smits, A., & Manninen, J. (2019). Teachers as users of ICT from the student perspective in higher education flipped classroom classes. *Seminar.Net: Media, Technology & Lifelong Learning*, *15*(1), 1–15.

Spante, M., Karlsen, A. V., Nortvig, A.-M., & Christiansen, R. B. (2014). Cross-Border Collaboration in History among Nordic Students: A Case Study about Creating Innovative ICT Didactic Models. In *IAFOR Journal of Education* (Vol. 2). doi: 10.22492/ije.2.2.02

Stockless, A., Villeneuve, S., & Gingras, B. (2018). Maitrise d'outils technologiques : son influence sur la compétence TIC des enseignants et les usages pédagogiques | Mastery of Digital Tools: The Influence on Information and Communication Technologies Competency and Pedagogical Use. *Canadian Journal of Learning and Technology*, *44*(2). doi: 10.21432/cjlt27581

Taimalu, M., & Luik, P. (2019). The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis. *Teaching and Teacher Education*, *79*, 101–110. doi: 10.1016/j.tate.2018.12.012

Tømte, C., Enochsson, A. B., Buskqvist, U., & Kårstein, A. (2015). Educating online student teachers to master professional digital competence: The TPACK-framework goes online. *Computers and Education*, *84*, 26–35. doi: 10.1016/j.compedu.2015.01.005

Tondeur, J., Aesaert, K., Prestridge, S., & Consuegra, E. (2018). A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers and Education*, *122*, 32–42. doi: 10.1016/j.compedu.2018.03.002

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2017). A comprehensive investigation of TPACK within pre-service teachers' ICT profiles: Mind the gap! *Australasian Journal of Educational Technology*, *33*(3), 46–60. doi: 10.14742/ajet.3504

Tseng, J.-J., Cheng, Y.-S., & Yeh, H.-N. (2019). How pre-service English teachers enact TPACK in the context of web-conferencing teaching: A design thinking approach. *Computers & Education*, *128*, 171–182. doi: 10.1016/j.compedu.2018.09.022

Tsybulsky, D., & Levin, I. (2016). SAMR Framework for Study Technology Integration in Science Education. In *New Perspectives in Science Education*. Retreived September 26, 2019, from http: https://m.tau.ac.il/~ilia1/perspectives-florence.pdf

Uerz, D., Volman, M., & Kral, M. (2018, February 1). Teacher educators' competences in fostering student teachers' proficiency in teaching and learning with technology: An overview of relevant research literature. *Teaching and Teacher Education*, Vol. 70, pp. 12–23. doi: 10.1016/j.tate.2017.11.005

Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. *Australasian Journal of Educational Technology*, *33*(3), 15–31. doi: 10.14742/ajet.3518

Vinck, D. (2018). *Humanidades Digitales*. Barcelona, España: Gedisa.

Wang, J., Tigelaar, D. E. H., & Admiraal, W. (2019). Connecting rural schools to quality education: Rural teachers' use of digital educational resources. *Computers in Human Behavior*, *101*, 68–76. doi: 10.1016/j.chb.2019.07.009

Wu, B., Hu, Y., Gu, X., & Lim, C. P. (2015). Professional Development of New Higher Education Teachers with Information and Communication Technology in Shanghai. *Journal of Educational Computing Research*, *54*(4), 531–562. doi: 10.1177/0735633115621922

Xiong, X. B., & Lim, C. P. (2015). Curriculum Leadership and the Development of ICT in Education Competencies of Pre-service Teachers in South China. *Asia-Pacific Education Researcher*, *24*(3), 515–524. doi: 10.1007/s40299-015-0238-1

Yildiz, T. (2016). The exploration of the relationships between the global competitiveness, the ICT and education. *Business, Management and Education*, *14*(2), 249–274. doi: 10.3846/bme.2016.320

Chapter 2

ICTs and their impact on academic results: an analysis based on the TPACK model

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Abstract

The integration of ICTs in the educational field has become an innovative technique for improving teaching-learning processes. This study aims to analyze the incidence of ICTs in the results of the Saber 11 tests applied in 2016, in Cundinamarca and Bogotá. Since integrating ICTs in the classroom should not be analyzed in isolation, the TPACK model will be taken as a frame of reference for this study. This model encompasses the two main components of education (pedagogy and content) and technology. A questionnaire was designed and applied to collect information on teachers' competencies about the TPACK model. Likewise, a quantitative analysis (linear regression and ANOVA) was proposed, taking the students' average results, grouped by the institution, as an independent variable. This allowed observing the variations of their behavior in contrast to the different independent variables. The relevance obtained by the students' socio-economic family status (Sig. = 0,000) to explain the behavior of the independent variable is highlighted, as well as the negative relationship between the technological infrastructure and the results obtained in the standardized tests of the government schools. In conclusion, the study corroborates previous research, stating that high socio-economic status institutions obtain better results than those of low status. However, the current integration of technology, pedagogy, and content is not relevant when explaining the Saber 11 test results.

Keywords

TPACK, education, Saber 11, socio-economic level, sector, teacher

Introduction

Nowadays, as well noted by Sacristán (2013), our society dwells in the era of communication, and the emergence of Information and Communication Technologies (ICTs) has expanded the horizons of knowledge. The author describes how ethnocentric problems of knowledge were overcome, and how now the focus lies in the broad knowledge of different social realities, due to how each society is open to perceiving itself. Therefore, the integration of ICTs in the educational field has resulted in an investment of human capital, which in turn has impacted how students learn and receive information, improving the economies of countries and standing out as a differentiating factor in the future against the global capitalist competition

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(Scherer, Tondeur & Siddiq, 2017). Huertas Montes & Pantoja Vallejo (2016) affirm that, when applying technological developments to teaching, an improvement in student learning is achieved, since it increases their motivation, their interest, and their creativity, it favors their ability to solve problems, it strengthens teamwork, it reinforces their self-esteem, and it allows greater learning autonomy.

Educational technology is here to stay thanks to its significant advantages over improving communication processes (Ferrés Prats, 2008). However, despite the situation mentioned above, doubts, criticisms, and reflections about the actual use of technology in training processes arise. Currently, several international studies such as those by Khe Foon & Thomas (2007), Sang, Valcke, Braak & Tondeur (2010), So & Kim (2009), among others, have demarcated the course to follow in order to consolidate a quality education that integrates information and communication technologies. The issues that the various studies have in common regarding integrating ICTs in education is that this process must be forged through articulating programmatic content, pedagogical knowledge, and technological knowledge.

ICTs are instruments that require diverse and specific knowledge to help consolidate educational quality. The integration of ICTs in the teaching process represents a tool that can facilitate the teaching-learning processes (Mishra & Koehler, 2006). However, assuming that the isolated integration of ICTs in the classroom will generate improvement is a mistake, because a model that allows the successful integration of the two main components of education (pedagogy and knowledge transmission) must be considered. Thus, ICTs become a support system for education. As mentioned in the first chapter, the TPACK model presented by Mishra & Koehler (2006) allows us to integrate technology, pedagogy, and knowledge to analyze the effect of ICT integration.

The model is divided into two types of knowledge that the teacher must possess to be able to make correctly integrate ICTs into their teaching methods. The first part is composed of three elements that are external to the technological context: content knowledge (CK), which refers to domain-specific knowledge of the subject pedagogical knowledge (PK),

which is the knowledge about practices, principles, and instructional strategies to manage the classrooms and organize the teaching of the subject pedagogical content knowledge (PCK), which is knowledge about which instructional approaches are adapted to the subject

The second part of TPACK is composed of new elements that arise from technological integration: technological content knowledge (TCK), which is knowledge about how the subject can be represented with the help of technology; technological pedagogical knowledge (TPK), referring to the use of technology to implement instructional practices, principles, and strategies; technological pedagogical content knowledge (TPCK), referring to the complex relationships between technology, pedagogy, and content that allow teachers to develop appropriate and specific teaching strategies for each context; and finally, technological knowledge (CT), related to several traditional and new technologies (Scherer et al., 2017). In short, it refers to the didactic knowledge of the content to the knowledge required by teachers to integrate technology in their teaching in any content area (Cabero, Marín & Castaño, 2015, p.15).

A study that analyzes the academic results obtained in a standardized test of secondary education and the possible relationship between the scores obtained with the process of ICT integration by teachers would expand the knowledge about adopting ICTs in education.

In Spain and Latin America, ICT integration has been the center of many research projects from different Universities and Congresses, such as the article "Validación de la aplicación del modelo TPACK para la formación del profesorado en TIC[5]" by Spaniards Julio Cabero, Verónica Marín and Carlos Castaño, as well as the theoretical and statistical validation that determines the feasibility of applying the TPACK model to teacher training in different areas of knowledge. An investigation carried out in the autonomous community of Andalusia revealed that when technology was properly implemented in the teaching methodology of an experimental group of students, compared with a control group to which a traditional methodology was applied, the mean results obtained at the end of the

[5] "Review of the application of the TPACK model in ICT teacher training".

teaching period –as collected in questionnaires regarding the knowledge acquired– increased significantly in the experimental group, both in motivation and in academic performance (Huertas & Pantoja, 2016).

Other studies such as Cuartas & Quintero (2014), combined the CTS approach with the TPACK model, is capable of generating a learning scenario in which there is a complete pedagogical, technological and content training that allows educating students who face a world which constantly undergoing technological changes. This is reflected in the Colombian project *TIT@ educación digital para todos*[6] developed in Cali, as well as in a proposal from Colombian teachers Medina & Parra (2017), which, after identifying the lack of critical thinking skills in the students of the institution in the area of Social Studies, showed that the application of the TPACK model increased the critical and participatory capacity of students, improving both teaching and learning processes in the classroom.

The inclusion of the TPACK model in the different academic scenarios around the world, and the extraordinary results it has shown in the face of the evolution of pedagogy and the new ways of teaching that technology offers, has a direct impact on what and how students of this century learn. The use of technological tools allows the knowledge taught in the classroom to be assimilated more quickly and efficiently. It also allows the teacher to reflect on their practice and include new strategies that improve student learning. As Molina Bernal states, virtual environments are a different opportunity for class management and are an essential strategy for teaching; above all, they contribute to developing and improving collaborative work and rescue significant learning (Molina, 2016, p.25).

Unfortunately, the TPACK model study about the impact it has on improving education is nil in Colombia. However, the implementation of different ICT integration policies in the educational field and the creation of accreditation systems have shown an interest in the country to improve the teaching-learning processes.

To know the effectiveness of the improvement processes applied in the Colombian educational field, the Colombian Institute for the Promotion

[6] TITA@ digital education for all.

of Higher Education (ICFES) –today, the Colombian Institute for the Evaluation of Education– was created in 1968. For this purpose, ICFES created the standardized academic tests, called Saber and Saber Pro Tests, which are applied in the first years of study –3rd, fifth and 9th grades– and at the end of secondary education, in the 11th grade. This article focuses on the Saber 11 Tests applied to students from the last grade of secondary education, which aims to verify the degree of development of competencies, provide elements for student self-assessment, and provide educational institutions with information about the competences of higher education candidates.

From the results obtained in existing research about the impact of technology on education, the generation of autonomous knowledge by students, improved social skills from contact with other communities, and the strengthening of visual content analysis can be positively highlighted. There are also negative results, such as the distraction and self-absorption of students due to the abuse of ICTs (Morrissey, 2008; Palacio Puerta & Cabrera Peña, 2017; Pradilla, Belloso, & Barboza, 2017). However, a detailed study on how ICTs affect, directly or indirectly, the Saber 11 tests have not been conducted so far. Dávila (2012), within the framework of the study of higher education in Colombia, first approached the issue by pondering over the incidence of ICTs in the Saber Protests results in nursing. Likewise, Vence-Pájaro promoted and established an ICT teaching method that allows improving the Saber 11 tests integrating it into the program Todas a Aprender. Although these two references in Colombia stand out, the first case does not review secondary education, while the second does not execute a specific study of how ICTs affect the results of the referred tests quantitatively.

Thus, research on the impact of using ICTs in teaching-learning processes based on the results of the Saber 11 tests for the year 2016 is timely. It is necessary to limit the research within a regional framework, identifying the incidence of ICTs, in the first instance, in the processes of the 4831 schools, both public and private, in Cundinamarca and Bogotá. It is necessary to have a transparent perspective model when facing the study method. The TPACK model provides an analysis perspective where contents, pedagogy, and technology are related to each other according

to the teacher's activities by integrating ICTs in the teaching-learning processes.

On the other hand, the results of the standard tests applied in 2016 in Cundinamarca and Bogotá take different directions. Thus, the research question is posed: What impact do ICTs have on improving the results of standard tests in the department of Cundinamarca and Bogotá? Considering this, other questions arise:

- What is the status quo of the ICT integration process in the various institutions of secondary education in Colombia?
- What are the factors of the TPACK model that directly affect the results of the Saber tests?

The general objective of this research is to analyze the incidence of ICTs in the improvement of the Saber 11 tests applied in 2016 in the department of Cundinamarca and Bogotá, using the TPACK model as an analysis perspective. To achieve this general objective, the following specific objectives are proposed:

- Design and apply measuring instruments with specific variables to evaluate the ICT integration process in secondary education institutions in Cundinamarca;
- Identify relevant factors in the integration of ICTs using the TPACK reference model;
- Determine the relationship between the ICT integration process and the results of the Saber tests.

Methodology

Analysis unit and population

The year 2016 was determined for the study period because it is the most recently updated database, while the total population was defined as 2845 schools that teach the 11th grade in the region of Bogotá and Cundinamarca, Colombia. The total population of institutions was reduced given that those who did not have grades 9, 10, and 11 were not included, and

some institutions that were definitively or temporarily closed. The sample was finally comprised of 157 schools, which collaborated with the research providing information necessary to carry out the quantitative analysis.

Data collection.

The measuring instrument for the research was made based on an adaptation of Cabero et al. (2015). Annex 1 shows the questionnaire used to collect the information. The instrument was developed with the help of the Google Form software tool, which allowed it to be interactive and straightforward as it was disseminated by email. This software also made it possible for it to reach many people surveyed, both in rural and urban areas.

The information collected provided primary data on the teachers of the institutions, such as mastery of the content in their specific work area, knowledge of technology and ability to be updated on these issues, different pedagogical techniques used, and their ability to integrate three components of the TPACK model in the classroom.

To collect the information from the institutions, the databases provided by ICFES and the Ministry of Education were used. Among the variables consulted are the institution's socio-economic level and that of the student body, its technological equipment, the global score obtained in the Saber 11 test for 2016, the number of teachers, the number of students enrolled, among others.

The instrument's first massive shipment was made from the schools' database provided by the ICFES of the year 2016. As shown in Figure 1, there is a decrease in the response rate in the last month because the institutions go on vacation.

After obtaining the corrected emails in the second phase of mass mailings, all mailings were sent again, managing to increase the response rate. However, the amount was still insufficient concerning the minimum number of expected responses. Therefore, other methods of approaching institutions were used: 239 calls and visits were made to 103 schools in Cundinamarca's municipalities, thus achieving an increase in the response rate.

In conclusion, the following graph summarizes the number of responses achieved, highlighting the increase that phase two had in the number of responses stands out.

On May 14, 2019, phase II was over, and the collection of information, leaving the instruments closed for online respondents.

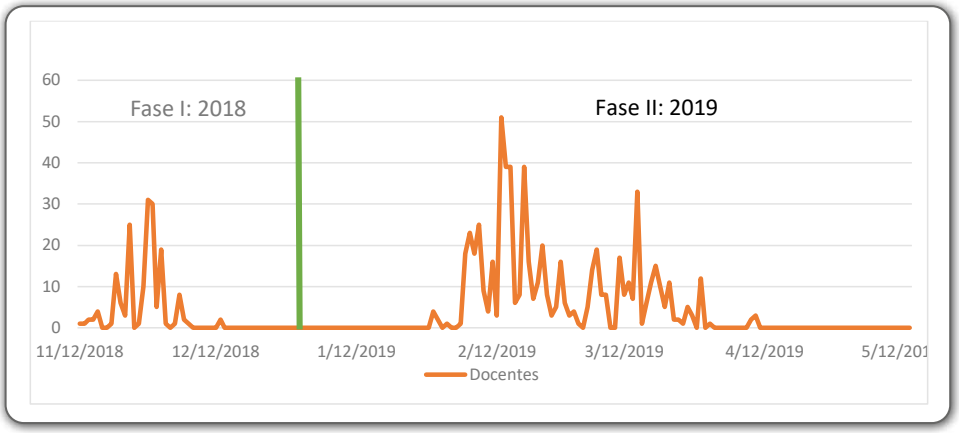

Figure 2.1. Comparison of the survey response rate between phase I and phase II. there is an increase in responses that differs by 175 from the first to the second phase –43 and 218, respectively (406% increase). In the case of teachers, the record of 633 new responses is also shown: in the first phase, there were 163, while in the second, there were 796 (257% increase).

Techniques and variables

Lineal regression.

Multiple studies use production functions to measure the impact of various factors on academic performance (Koshal, Koshal & Gupta, 2001; Longlong, Fengliang & Weifang, 2009; Melo, Ramos & Hernández, 2017). These models use production or cost functions to estimate efficiency measures. In this case, the model used starts with applying an explanatory model that allows analyzing the determining factors that affect the results obtained in the Saber 11 tests applied by the ICFES in Colombia. The applied model is a linear regression, as shown:

$$y_i = \mu + \beta X_i, + \varepsilon_i$$

Where μ represents the average interception; X, the explanatory variables; and ε, the random disturbance.

Using this model, it is assumed that heterogeneity is collected only by the constant term and that the β coefficients are constant for the different schools, allowing to assume that similar technologies are used. In this case, the dependent variable Y represents the average score obtained by the school in the Saber 11 tests of the year 2016 called "Average of Punt_Global", and as explanatory variables (X) the rest shown in Table 2.1.

Table 2.1
Description of the variables and sources of information

Name	Example	Description	Source
Name of the institution	Example: INEM FRANCISCO DE PAULA SANTANDER.	Name of the headquarters where the teacher works.	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
DANE Code	Example: 317380000942	DANE Code of the Institution. It was used as the unit of analysis identifier.	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
Average of Punt_Global	Example: 252,37	Average total score obtained by the institution evaluated.	ICFES data base 2016.
Average of Fami_ Estratovivienda	Example: 2 Values: 6 1 2 3 4	Average socioeconomic status of the residence of the institution's students.	ICFES data base 2016.
TPACK	Example: 4 Values: 5 1 2 3 4 5	The ability of the teaching staff to incorporate pedagogy, technology and content into classrooms is valued.	Structured questionnaire for teachers.

Name	Example	Description	Source
Total teachers	Example: 120	Number of teachers working in the institution	ICFES data base 2016.
Total equipments	Example: 50	Indicates the capacity of the school's technological infrastructure.	ICFES data base 2016.
Sector Num	Example: NOT government Values: 2 NOT government = 0 government = 1	Nature of the educational institution (which can be public or private).	ICFES data base 2016.

The descriptive statistics of the quantitative variables are shown in table 2.2.

Table 2.2
Descriptive statistics of the variables

Variable	Maximum value	Minimun value	Average	Deviatión
Average of Punt_Global	375,98	200,78	283,14	32,65
Average of Fami_ Estratovivienda	5,70	0,00	2,42	0,98
TPACK	5,00	1,50	3,79	0,63
Total teachers	187	0	41,90	34,39
Total equipments	796	0	154,74	154,68
Sector Num	1	0	0,5	0,50

Note: *Total equipment* variable presents the most dispersion since its deviation (154,68) is very close to the average (154,74). This indicates that technological resources vary greatly from one institution to another. The next deviation close to its average is presented by the variable Total teachers. It is therefore inferred that the teaching staff changes according to the institution. To a lesser extent, the variables Average of Punt_ Global, TPACK and Sector Num show dispersion, although the differences between institutions are not as significant.

ANOVA.

The Analysis of Variance technique (ANOVA) is one of the most used techniques in data analysis in experimental designs. It is used when the means of more than two groups need to be contrasted, so it can be seen as an extension of the t-test for differences of two means. Basically, it is a study that allows dividing the variance of the dependent variable into two or more components, each of which can be attributed to an identifiable source (variable or factor) (Tamayo, 2000).

In this investigation, the ANOVA technique was used to observe the relationship between the different variables that were used for the linear regression and the socio-economic status of the establishment –mainly to check if the means of the variables "Average of Punt_Global" and "TPACK" vary according to the socio-economic level of the establishment. Likewise, the trend of the components of the TPACK model, separated in pairs and individually, in relation to the average of the socio-economic status of the institution.

Results

Linear regression and ANOVA

For the statistical treatment, the SPSS software was used, and the following results were obtained:

Table 2.3
Model summary

R	R^2	Adjusted R^2	Standard error
0,865	0,749	0,740	16,9040

Note: the model, with all the variables and data obtained from the investigation, offers a good adjustment when explaining the Average dependent variable of Punt_Global, reaching an adjusted R^2 of 0,740.

Table 2.4 shows the independent variables that are relevant and significant to explain the behavior of the independent variable obtained in 2016.

Table 2.4
Model coefficients

Coefficients	Non-standardized coefficients		Standardized coefficients	t	Sig.
	B	Dev. Error	Beta		
Constant	236,845	11,081		21,375	0,000
Average of Fami_ Estratovivienda	21,940	1,953	0,660	11,236	0,000
TPACK	-1,283	2,520	-0,022	-0,509	0,612
Total teachers	0,147	0,047	0,152	3,108	0,002
Total equipments	0,003	0,012	0,013	0,249	0,804
Num Sector	-16,857	4,276	-0,255	-3,942	0,000

Note: the significant variables are: *Average of Fami_Stratovivienda, Total Teachers and Sector Num*. Of these variables, the most relevant when explaining the variation in the results obtained in the Average variable of Punt_Global are the Average of Fami_ Estratovivienda and Sector Num.

Thus, an increase of one unit in the Average of Fami_Estratovivienda variable would increase the results of the Average of Punt_Global variable by 0.660 units. Similarly, a growth in a unit in Sector Num would cause a decrease of 0.255 units of the dependent variable. This is because the Sector variable is divided between Non-government represented with the value 0 and Government represented with the value 1. Therefore, the model indicates that a government school would have a lower result in the state tests. In the case of the Total Teachers variable, it positively affects the dependent variable, so an increase of one unit in this variable would increase the Average of Punt_Global by 0.152 units.

The TPACK and Total Equipment variables affect the dependent variable to a lesser extent, although its contribution is not significant.

To observe the behavior of the dependent variable, a selection variable was used that limits the analysis to a subset of cases that have a particular value. In this case, the Sector selection variable was used, with the Government and Non-government values. Table 2.5 shows the model information with the Non-government Sector selection variable, the model offers a

good fit, although not as good as the previous general model. It is possible to explain the model with an adjusted R^2 of 0,640.

Table 2.5
Summary of the model with the Non-government Sector selection variable

R		R^2	Adjusted R^2	Standard error
NUM SECTOR = 0 (Selected)	NUM SECTOR = 0 (Selected)			
0,812	0,575	0,659	0,640	17,8753

Table 2.6 shows the independent variables that are relevant and significant to explain the behavior of the score obtained in 2016.

Table 2.6
Model coefficients with the Non-government Sector selection variable

Coefficients	Non-standardized Coefficients		Standardized Coefficients	t	Sig.
	B	Desv. Error	Beta		
Constant	228,489	17,184		13,297	0,000
Average of Fami_ Estratovivienda	20,311	2,447	0,615	8,301	0,000
TPACK	0,278	4,037	0,005	0,069	0,945
Total teachers	0,276	0,126	0,276	2,183	0,032
Total equipments	0,028	0,041	0,087	0,685	0,496

Note: the variables Average of Fami_Stratovivienda and Total Teachers are significant.

The variable that has more relevance explaining the variation in the results in the Average of Punt_Global variable, is the Average of Fami_Estratovivienda.

Also, an increase of one unit in the Fami_Estratovivienda Average variable would increase the results of the Punt_Global Average variable by

0.615 units. To a lesser extent, the Total Teachers variable affects the dependent variable, as this variable increases by one unit, it would increase the results of the Average Punt_Global variable by 0.276. The TPACK and Total Equipment variables affect the dependent variable to a lesser extent, although their participation is not significant.

The results obtained from the model are shown below using the Government Sector variable as the selection variable. Table 2.7 shows the model information:

Table 2.7
Summary of the model with the selection variable Government Sector

R		R^2	Adjusted R^2	Standard error
NUM SECTOR = 1 (Selected)	NUM SECTOR = 1 (Unselected)			
0,693	0,749	0,481	0,451	14,4923

Note: the model offers the worst adjustment compared to the regressions seen above, even though it is possible to achieve an adjusted R^2 of 0,451.

Table 2.8
Model coefficients with the Government Sector selection variable

Coefficients	Non-standardized coefficients		Standardized coefficients	t	Sig.
	B	Dev. Error	Beta		
Constant	222,910	10,816		20,609	0,000
Average of Fami_ Stratovivienda	23,122	3,235	0,678	7,148	0,000
TPACK	-0,496	2,948	-0,015	-0,168	0,867
Total teachers	0,038	0,050	0,074	0,758	0,451
Total equipment	-0,008	0,011	-0,071	-0,785	0,435

Note: The table shows the independent variables that are relevant and significant to explain the behavior of the average of Punt_Global.

As can be seen in Table 2.8, the significant variable is the Fami_Estratovivienda mean, which coincides with the previous regressions. In the same way, an increase of one unit in the Fami_Estratovivienda mean would increase the results of the Punt_Global mean variable by 0,678 units. The variables TPACK, Total teachers and Total equipments are less relevant in the independent variable, but their participation does not contribute to explaining the behavior of the independent variable.

However, in this case, the B coefficient of the Total equipment variable has negative values, which suggests that increasing it would decrease the Punt_Global mean. The model would indicate that government or state schools with a better technological infrastructure would obtain lower results in the Saber 11 tests than institutions without this resource. Compared to the previous regression, the models would denote that, unlike government schools, non-government institutions that have a good technological infrastructure will obtain better results than non-government schools that do not and, compared to the general regression, than government schools.

A comparison between the three previous regressions would indicate that, for both government and non-government institutions, the family's socio-economic sector directly affects the average score that students will obtain. Similarly, in the general regression and in the regression with the government sector variable, the TPACK variable has negative values in the non-standardized B coefficient. This would suggest that institutions whose teachers have greater capacity for integrating pedagogy, content, and technology obtain inferior results in the Saber 11 tests. To understand the result presented by the non-standardized coefficient, different ANOVA tests represented in graphs were generated with the results obtained from the teacher survey which evaluated their knowledge about TPACK and their competences to apply it in the classroom, as well as the average socio-economic status of the establishment.

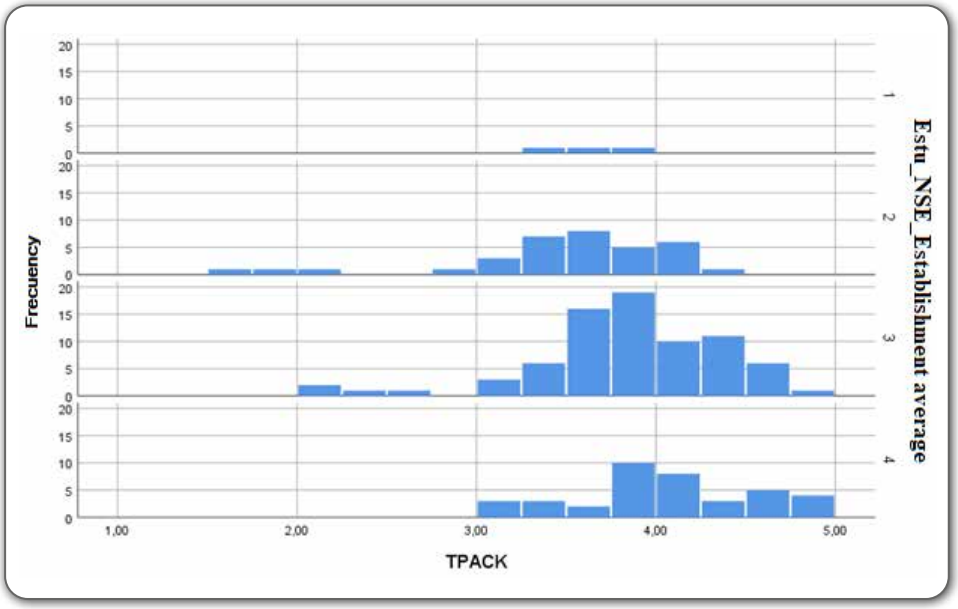

Figure 2.2. Comparative histogram. TPACK and the Estu_NSE_Establishment average variables. The average of the TPACK variable tends to increase along with the socio-economic status of the establishment. However, the TPACK score of status 1 correlates with status 3 and 4. Contrary to expectations, status 1 does not follow the same trend as the others: for example, status 2 starts with a low score that then increases. In addition, it is observed that the number of records of status 1 is significantly smaller compared to the records of the other status.

A mean difference graph (ANOVA test), presented below, helped to understand the behavior of the different variables that make up the TPACK separated in pairs, and the TPACK as a model in relation to the socio-economic status. It was developed in order to explain the trend presented by status 1.

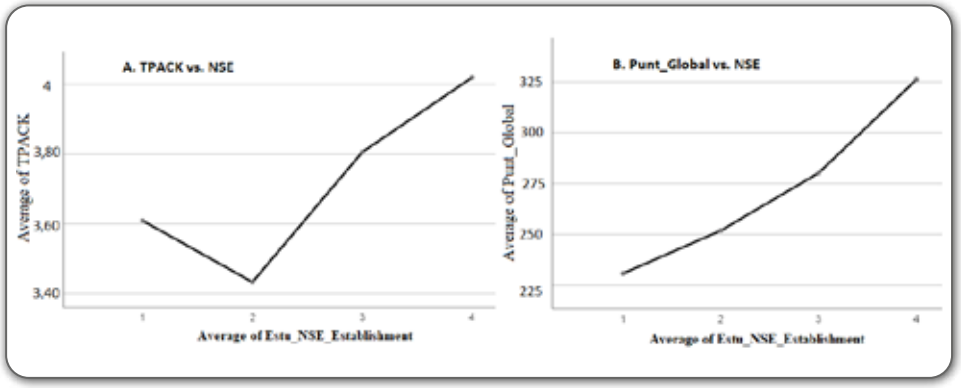

Figure 2.3. Average of TPACK and Average of Punt_Global with Average of Estu_NSE_Establishment. The behavior of the socio-economic status 1 with respect to the average obtained by the TPACK is higher than status 2 and similar to status 3 and 4. This does not match the trend of the other status nor the average scores obtained in the Saber 11 tests from institutions with a higher status but with a similar TPACK score.

As can be analyzed from graph 2.3B, the overall score obtained by the institutions in 2016 increases with the socio-economic level of the institution, which coincides with the result obtained from the general regression, where an increase in the socio-economic status also improves the results obtained in the overall score. However, this does not correspond to the trend of the histogram and graph 2.3A, where the socio-economic status does not follow the same inclination.

From the survey carried out, an average score was obtained by the teachers of the institutions on their knowledge about the different components of the TPACK. The graphs of means that compared the components of the TPACK and their interaction with the socio-economic status were developed in order to explain the behavior of the socio-economic status versus the results of the TPACK. Below are the graphs of means between the socio-economic status of the establishment and the content, pedagogy, and technology individually.

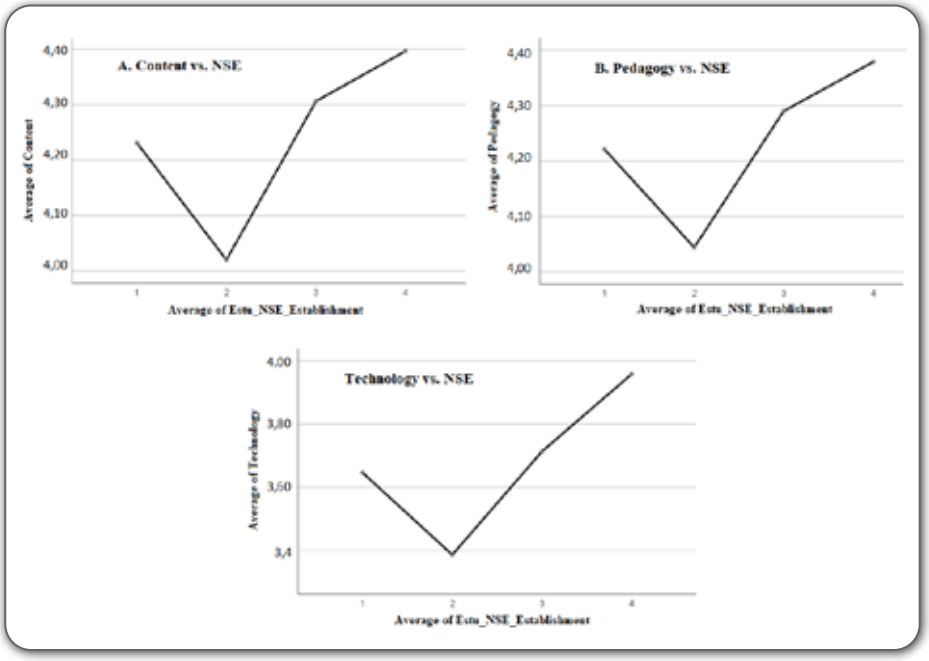

Figure 2.4. Average of TPACK components by Average of Estu_NSE_Establishment. When observing the three graphs that compare the three components of the TPACK with the socio-economic status of the institutions, the same behavior from the histogram and the graphs of previous average is observed, since the results of the teachers' competences on content, pedagogy and technology increase with the socio-economic status of the institution. However, status 1 has a high result compared to the behavior of the other status. Even so, it is not consistent with the results in the average global score, since status 1 has the lowest average.

To obtain a clearer view of the behavior of the socio-economic status variable of the institution, graphs of the TPACK components separated by pairs were made, as shown in graph 2.5 where the pedagogy and content are compared with the socio-economic status of the establishment.

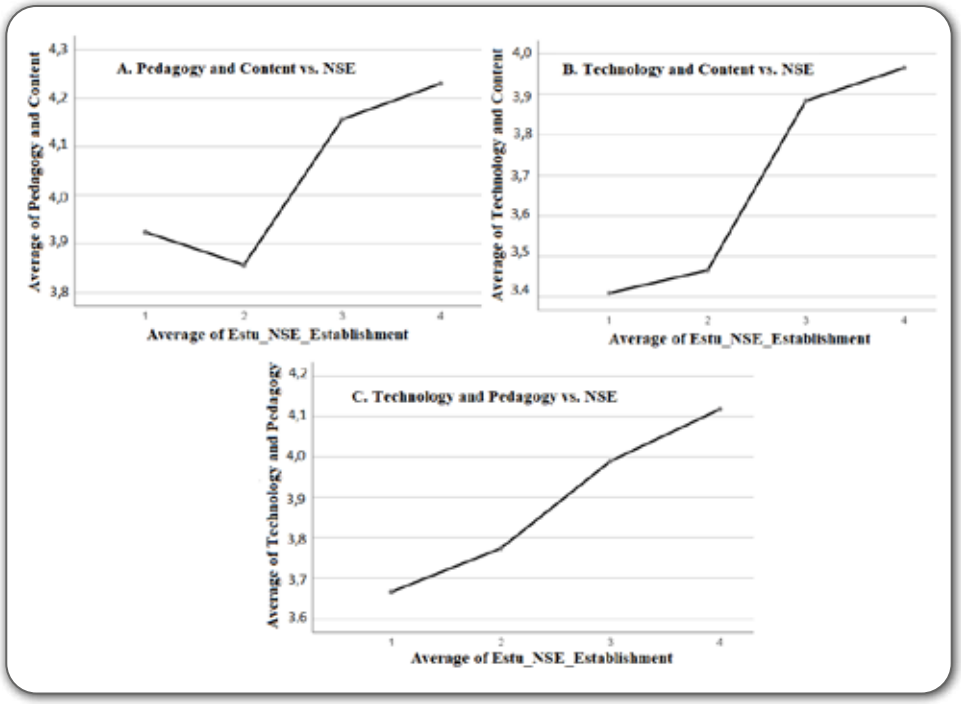

Figure 2.5. Average of TPACK components grouped in pairs and Average of Estu_NSE_Establishment. The behavior presented by status 1 is similar to the previous graphs. However, the ability of teachers to integrate pedagogy and content is not consistent with the scores obtained in the Saber 11 tests. It is expected that, when the ability of a teacher to incorporate content and pedagogy in the classroom is better, it positively influences the results of the average score in the tests by students.

However, graphs 2.5B and 2.5C, where technology and content, technology and pedagogy are compared with the socio-economic status, it can be seen that the tendency to increase along with the status is preserved. Likewise, the relationship between the status and the score in the Saber 11 tests corresponds to the results of the ability of the teaching staff to integrate the TPACK components.

Consequently, based on the results obtained in the means graphs and, in particular, the histogram, it was inferred that the behavior demonstrated by status 1 does not follow a logical trend because it behaves similarly to status 3 and 4. Despite this, the results obtained in the Saber 11 tests are

the lowest compared to the other status. Because of this, the records in the database were reviewed which allowed acknowledging that there were only three records belonging to status 1. Therefore, they were considered isolated results, without the strong enough information to represent the entirety of status 1.

Accordingly, those corresponding to status 1 were excluded from the registers and a regression and new ANOVA tests were performed again, in order to establish a more accurate view of the relationship between the TPACK model and the results of the Saber 11 tests.

Table 2.9
Model summary (without status 1)

R	R^2	Adjusted R^2	Standard error
0,846	0,716	0,708	17,5337

Note: the model offers a good fit when explaining the behavior of the dependent variable, reaching an R^2 of 0,708. This result is very similar to the one obtained in the first regression.

Table 2.10
Model coefficients (without status one)

Coefficients	Non-standarized coefficients		Standarized coefficients	t	Sig.
	B	Desv. Error	Beta		
Constant	213,983	9,761		21,922	0,000
Average of Fami_ Estratovivienda	26,468	1,566	0,806	16,900	0,000
TPACK	0,882	2,576	0,016	0,343	0,732
Total teachers	0,115	0,049	0,122	2,363	0,019
Total equipments	-0,016	0,011	-0,076	-1,476	0,142

Note: this are the variables that explain the behavior of the independent variable.

The information presented in Table 2.10 reaffirms the positive relationship between the TPACK and the result of the average global score found

in the previous regressions, however, its contribution is not significant. The variables of Fami_Estratovivienda and Total teachers are the most relevant, as in the previous regressions. Of these variables, the one that has the greatest significance is the Fami_Estratovivienda average, since increasing this variable in one unit would increase the overall score by 0,806 units, this being the highest value achieved from the previous regressions.

To a lesser extent, the Total teacher's variable turns out to be outstanding when explaining the behavior of the independent variable, since increasing this variable by one unit would increase the global score by 0,122 units. With this, the positive influence of a good infrastructure in the teaching staff on the results of the Saber 11 tests is confirmed. However, the Total equipment variable continues to have a negative value in its non-standardized B coefficient, which would indicate that schools that have a better technological infrastructure would obtain lower results in the Saber 11 tests.

Table 2.11 shows the summary of the model achieved by discarding the records of the institutions of status 1, using the Sector as the selection variable once again.

Table 2.11.
Summary of the model with the selection variable Government Sector (without status 1)

R		R^2	Adjusted R^2	Standard error
NUM SECTOR = 1 (Selected)	NUM SECTOR= 1 (Unselected)			
0,685	0,741	0,469	0,437	13,7349

Note: the model offers a bad adjustment compared to the other models when explaining the dependent variable, as it reaches an adjusted R^2 of 0,437.

This result is like the obtained in Table 2.7, also using the Government Sector selection variable, which is not significantly different from the original model. The following table shows the independent variables that are significant to explain the behavior of the Average of Punt_Global:

Table 2.12
Model coefficients with the Government Sector selection variable (without status one)

Coefficients	Non-standarized coefficients		Standarized coefficients	t	Sig.
	B	Dev. Error	Beta		
Constant	223,494	10,329		21,638	0,000
Average of Fami_ Estratovivienda	21,630	3,139	0,667	6,890	0,000
TPACK	0,619	2,822	0,021	0,219	0,827
Total teachers	0,028	0,048	0,058	0,580	0,564
Total equipments	-0,011	0,010	-0,104	-1,129	0,263

Note: the significant variable is the Fami_Estratovivienda Average, as well as the regressions presented above

Table 2.12 reaffirms that students belonging to institutions of higher status will obtain better results in the Saber 11 tests. However, the significant difference between the previously presented models is the value of the standardized Beta coefficient when taking a positive value, as it shows that the TPACK is positively related to the results obtained in the Average of Punt_Global. According to this, in the institutions that have a better-trained teaching staff in the integration of ICTs to classrooms, students will obtain better results in the Saber tests than those from institutions that do not have them. Likewise, teachers with better skills to include the TPACK model into their teaching methods are in institutions of high socio-economic status.

However, the statement only applies to the government sector, so it was necessary to perform a regression again using the Non-Government Sector as the selection variable. In order to corroborate the results achieved with the government sector or if, on the contrary, the non-government sector behaves completely differently. Table 2.13 shows the model summary.

Table 2.13
Summary of the model with the selection variable Sector Non-government (without status 1)

R		R^2	Adjusted R^2	Standard error
NUM SECTOR = 0 (Selected)	NUM SECTOR = 0 (Unselected)			
0,812	0,542	0,659	0,640	17,8753

Note: the model presents a good adjustment to explain the behavior of the dependent variable, similar to the regression made previously with the same Non-government Sector selection variable, reaching an R^2 of 0,640.

The relevant variables to explain the behavior of the global score are presented in table 2.14.

Table 2.14
Model coefficients with the Non-government Sector selection variable (without status 1)

Coefficients	Non-standarized coefficients		Standarized coefficients	t	Sig.
	B	Desv. Error	Beta		
Constant	228,489	17,184		13,297	0,000
Average of Fami-Estratovivienda	20,311	2,447	0,615	8,301	0,000
TPACK	0,278	4,037	0,005	0,069	0,945
Total teachers	0,276	0,126	0,276	2,183	0,032
Total equipments	0,028	0,041	0,087	0,685	0,496

Note: the variables Fami_Estratovivienda and Total teachers turn out to be significant to explain the behavior of the score. Of these variables, the most significant is the Fami_Estratovivienda average, since increasing it by one unit would increase the results of the Punt_Global average variable by 0,615 units.

To a lesser extent, the Total teachers variable turns out to be significant, since increasing it by one unit would increase the average of the Saber 11 tests by 0,276 units. As in the previous models, the model indicates that the institutions that have a better infrastructure in the teaching staff will have better results in the overall score.

Likewise, ANOVA tests were carried out again to determine, with greater clarity, the relationship that exists between the different components of the TPACK and the model in general with the socio-economic status of the institution, without taking into account the isolated cases of status 1. They were executed in order to make a comparison with the results obtained in the previous graphs and to corroborate the positive relationship between the factors that compose it, the TPACK as a whole and the Saber 11 tests.

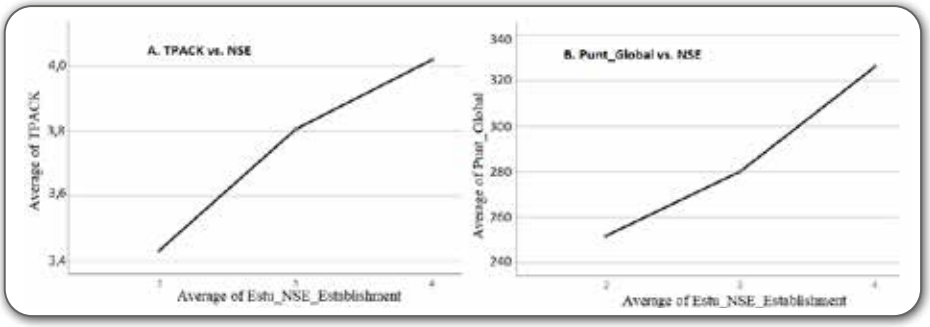

Figure 2.6. Average of TPACK and Average of Punt_Global with Average of Estu_NSE_Establishment. In contrast to Figure 2.4, it is observed that, when removing status 1, all socio-economic status follows the same tendency to increase the TPACK variables and the Average of Punt_Global as the status increases.

As can be seen in the previous graphs, the average of the TPACK competencies of the teachers evaluated in the survey and the average of the overall score increase as the socio-economic level of the establishment increases. According to this, the institutions of the upper status, in which teachers have a better ability to apply the TPACK model in their classrooms, will obtain better results than those that do not.

ANOVA tests allowed comparing the ability of teachers to integrate TPACK components in pairs and the socio-economic level of the establishment. The behavior of the variables can be observed in the following graphs:

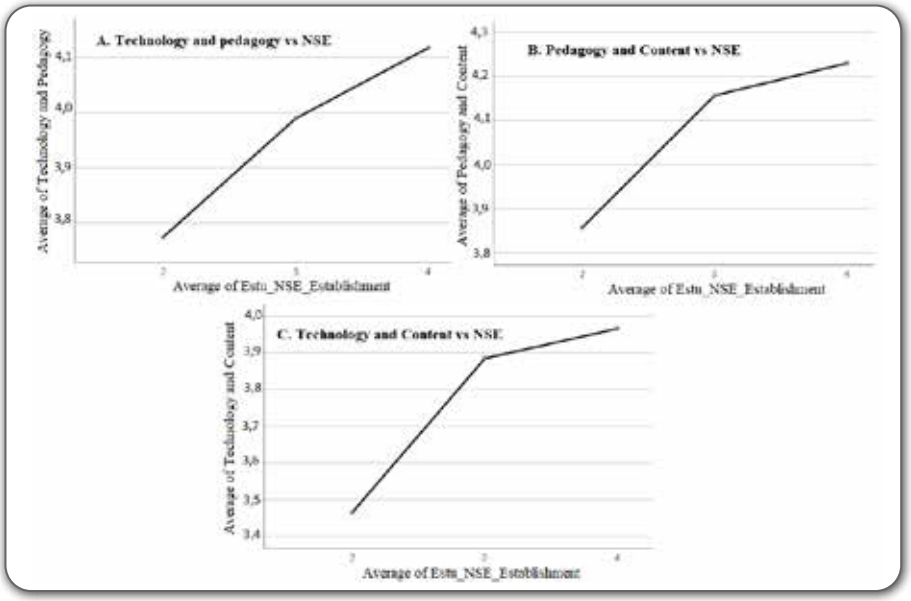

Figure 2.7. Average of TPACK components and average of Estu_NSE_Establishment. The variables Technology and Pedagogy, Pedagogy and Content, and Technology and Content tend to increase as the socio-economic status increases, which is consistent with what is contemplated in Figure 2.7, where the TPACK and the global average score also increase with the growth of the status. The above reaffirms the foregoing in which the institutions that have teachers better trained in the integration between technology, pedagogy, and content achieve better results in the Saber 11 tests. According to the graphs, these institutions are from high status.

Finally, an ANOVA test was performed with the individual components of the TPACK and the socio-economic status:

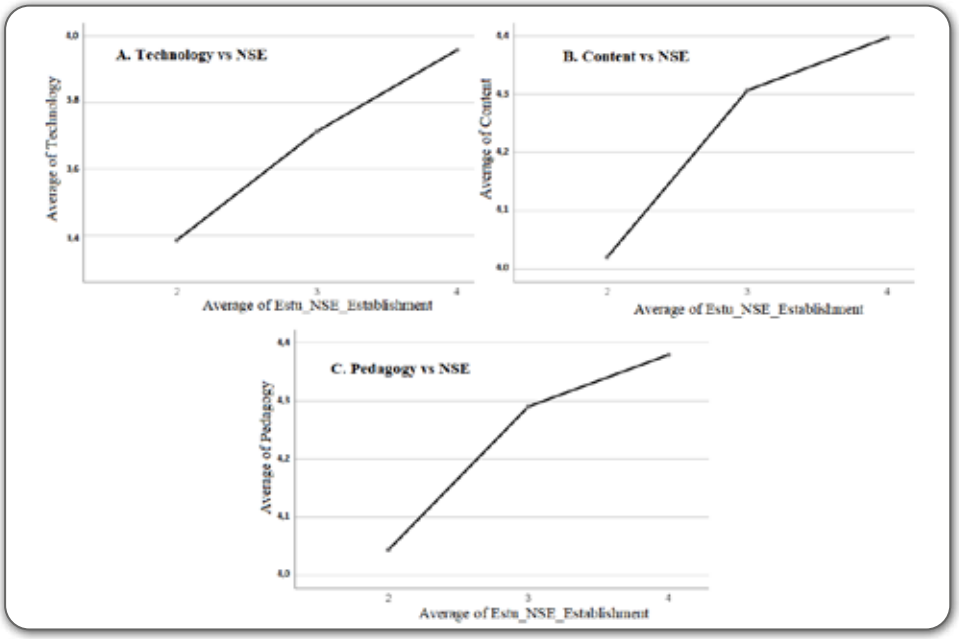

Figure 2.8. Average of TPACK components grouped in pairs and Average of Estu_NSE_Establishment. The tendency of the variables to increase as the status increases is maintained. This confirms that the isolated cases of status 1 were skewing the sample and negatively affecting the influence of TPACK.

Finally, it is observed in all the graphs that both the capacity of the teaching staff to work and implement the TPACK model, as well as its components separated in pairs or individually, increases as the socio-economic status of the establishment increases, maintaining a positive relationship with the scores obtained in the Saber 11 tests of the institutions. Likewise, the number of teachers that the institution has and their ability to integrate TPACK in the classroom increases with the socio-economic status of the institution, as well as the Average of Punt_global.

Discussion

The study carried out corroborates the results obtained in previous studies, verifying that a school with a low-income student population will have lower state test results. In this sense, as stated by Celemín & Flórez (2018), the students' socio-economic status has a decisive influence on the

students' results in the Saber 11 tests. In addition to the above, this study allows us to conclude that, depending on the institution's condition to which the students belong, whether public or private, the results obtained will be different. Thus, a government school tends to have lower results than a private one.

Likewise, the negative relationship between the Total equipment variable and the average global score found in the linear regression of the Government Sector selection variable stands out, which allows us to deduce that the government institutions with better technological infrastructure will obtain lower results the Saber 11 tests. A possible cause of this result, as stated by different authors (Morrissey, 2008; Palacio Puerta & Cabrera Peña, 2017; Pradilla et al., 2017), maybe the adverse effects of misuse of ICTs in the classroom, such as student distraction and self-absorption.

Finally, given the study results, it is observed that the current integration of technology, pedagogy, and content from the staff are not relevant inputs when explaining the test results of Saber 11. This leads to raising the hypothesis, for further studies, that there is a lack of training of teachers to make a correct articulation between technology, pedagogy, and content, which would improve the learning process of the skills necessary to obtain a good result in standardized tests.

References

Cabero, J., Marín, V., & Castaño, C. (2015). Validation of the application of TPACK framework to train teacher in the use of ICT. *@tic. Revista d'innovació Educativa*, 0(14), 13-22. doi: 10.7203/attic.14.4001

Celemín, J. & Flórez, R. (2018). Percepciones sobre factores que inciden en los resultados de las pruebas Saber 11 de la población sorda. Una mirada desde tres instituciones educativas de Bogotá D.C., Colombia. *Revista de La Facultad de Medicina*, 66(3), 349-356. doi: 10.15446/revfacmed.v66n3.61038

Cuartas, M., & Quintero, V. (2014). Formación docente en el desarrollo de competencias digitales e informacionales a través del modelo enriquecido TPACK*CTS*ABP. *Congreso Iberoamericano de Ciencia, Tecnología, Innovación y Educación*, 20. Retrieved from https://www.oei.es/historico/congreso2014/contenedor.php?ref=libres2

Dávila, C. (2012). Estilos de aprendizaje en estudiantes de enfermería y su relación con el desempeño en las pruebas Saber Pro. *Journal of Learning Styles*, 1-14. doi: 10.1017/CBO9781107415324.004

Ferrés Prats, J. (2008). *La educación como industria del deseo: Un nuevo estilo comunicativo*. Madrid, España: Gedisa.

Huertas Montes, A., & Pantoja Vallejo, A. (2016). Efectos de un programa educativo basado en el uso de las TIC sobre el rendimiento académico y la motivación del alumnado en la asignatura de tecnología de educación secundaria. *Educación XX1*, 19(2), 229-250. doi: 10.5944/educxx1.16464

Khe Foon, H., & Thomas, B. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. Educational *Technology Research and Development*. doi: 10.1007/s11423-006-9022-5

Koshal, R. K., Koshal, M., & Gupta, A. (2001). Multi-product total cost function for higher education: a case of bible colleges. *Economics of Education Review*, 20, 297–303.

Longlong, H., Fengliang, L., & Weifang, M. (2009). Multi-product total cost functions for higher education: The case of Chinese research universities. *Economics of Education Review*, 28(4), 505-511. doi: 10.1016/J.ECONEDUREV.2008.11.002

Medina R., L. L., & Parra B., L. R. (2017). *El TPACK como modelo generador de estrategias didácticas para el área de Ciencias Sociales en el grado décimo de la institución John F Kennedy de Arbelaez*. Retrieved from http://recursos.portaleducoas.org/sites/default/files/5135.pdf

Melo-Becerra, L. A., Ramos-Forero, J. E., & Hernández-Santamaría, P. (2017). La educación superior en Colombia: situación actual y análisis de eficiencia. *Revista Desarrollo y Sociedad*, 78(1), 59-111. doi: 10.13043/DYS.78.2

Mishra, P., & Koehler, M. J. (2006a). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 108(6), 1017-1054.

Molina Bernal, I. M. (2016). Algunas consideraciones para la dirección de clases. In Autora (Ed.), *Los retos de la didáctica: lecturas para el siglo XXI* (p. 175). Bogotá, Colombia: Universidad Sergio Arboleda.

Morrissey, J. (2008). *El uso de TIC en la enseñanza y el aprendizaje. Cuestiones y desafíos*. (Vol. 2). Buenos Aires, Argentina: Fondo de Naciones Unidas para la infancia.

Palacio Puerta, M., & Cabrera Peña, K. I. (2017). La gobernanza de internet como plataforma para impulsar políticas en la educación con TIC. El caso de Colombia. *OPERA*, (21), 5. doi: 10.18601/16578651.n21.02

Pradilla, J., Belloso, O., & Barboza, J. (2017). *Factors affecting the effectiveness of ICT in learning technology*. (2015), 181-195.

Sacristán, A. (2013). *Sociedad del conocimiento, tecnología y educación*. Retrieved from https://dialnet.unirioja.es/servlet/articulo?codigo=6068140

Sang, G., Valcke, M., Braak, J. van, & Tondeur, J. (2010). Student teachers' thinking processes and ICT integration: Predictors of prospective teaching behaviors with educational technology. *Computers and Education*. doi: 10.1016/j.compedu.2009.07.010

Scherer, R., Tondeur, J., & Siddiq, F. (2017). On the quest for validity: Testing the factor structure and measurement invariance of the technology-dimensions in the Technological, Pedagogical, and Content Knowledge (TPACK) model. *Computers and Education*, 112, 1–17. doi: 10.1016/j.compedu.2017.04.012

So, H.-J., & Kim, B. (2009). Learning about problem based learning: Student teachers integrating technology, pedagogy and content knowledge. *Australasian Journal of Educational Technology*, 25(1). doi: 10.14742/ajet.1183

Tamayo, I. (2000). Análisis De Varianza Con Spss 8.0. *Apuntes_Estadística*, 25–31.

Vence Pájaro, L. M. (2014). Uso pedagógico de las TIC para el fortalecimiento de estrategias didácticas del programa todos a aprender. *Congreso Iberoamericano de Ciencia, Tecnología, Innovación y Educación*, 17. Buenos Aires.

Annex 1
Questionnaire used to collect the information

SURVEY ON PEDAGOGICAL AND TECHNOLOGICAL COMPETENCES IN CLASSROOM
Based on Cabero, J., Marín, V., & Castaño, C. (2015).
* Required

1. Email address

_____

2. Name of the Institution where you work (all in capital letters) *

_____

3. Municipality in which the Institution is located *

_____

4. Gender *

_____

5. Type of contract

_____

6. Current age *

_____

7. Years of experience as a teacher *

_____

8. Years working in the current Institution *

_____

9. At what educational level do you teach your subjects? *

_____

10. Have you implemented mobile applications during the class? If so, what applications have you used? *

_____

11. Do you consider that the use of mobile applications in the classroom helps you in the teaching process? *

12. Mark only one oval.

- ( ) Yes
- ( ) No
- ( ) I have not considered

12. What is your main area of teaching? * Mark only one oval.

- ( ) Mathematics
- ( ) Language
- ( ) Humanities / Social Sciences / Philosophy
- ( ) Natural Sciences (Physics, Chemistry and Biology)
- ( ) English / Foreign Language

13. I have enough knowledge about my area * *Mark only one oval.*

	1	2	3	4	5	
POOR	( )	( )	( )	( )	( )	EXCELLENT

14. I apply a thinking model that is consistent with my area * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	( )	( )	( )	( )	( )	STRONGLY AGREE

15. I have various methods and strategies to develop my knowledge in my area* *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	( )	( )	( )	( )	( )	STRONGLY AGREE

2. Pedagogical knowledge of the content

16. I can effectively select pedagogical approaches to guide student thinking and learning in my area* *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

3. Technological knowledge of the content

17. I know what technologies to apply to understand and develop content about my area * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

4. Technological-pedagogical knowledge of the content

18. The content of my classes articulates the pedagogical technologies and approaches * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

19. I select technologies that improve the content that I teach in the classroom* *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

20. I guide other people to use content, technologies and pedagogical approaches in my educational institution * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

21. I select technologies that improve the way I impart content in the classroom * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

If you teach another area, please request another questionnaire

5. Technological knowledge

22. I easily solve technology problems in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

23. I easily assimilate technological knowledge * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

24. I keep up to date with new technologies * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

25. I often use and test technology tools in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

26. I know different kinds of technologies * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

27. I have the technical knowledge to use technology efficiently * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

28. I can work with different technological devices and applications * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

6. Pedagogical knowledge

29. I know how to evaluate the performance of students in the class room * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	◯	◯	◯	◯	◯	STRONGLY AGREE

30. I adapt my pedagogical approach to what the students always as similate * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

31. I adapt my pedagogical method to students with different learning structures * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

32. I know several ways to assess student learning * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

33. I apply a wide variety of pedagogical strategies in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

34. I am aware of the most common successes and mistakes of stu dents in relation to understanding the content * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

35. I organize and maintain an active dynamic in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

7. Technological-pedagogical knowledge

36. I select technologies that improve the pedagogical strategies that I apply in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

37. I select technologies that improve student learning in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

38. I reflect on the influence of technology on the pedagogical strategies that I use in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	◯	◯	◯	◯	◯	ALWAYS

39. I take a critical stance on how to use technology in the classroom * *Mark only one oval.*

	1	2	3	4	5	
NEVER	☐	☐	☐	☐	☐	ALWAYS

40. I can adapt the technologies that I am learning to different pedagogical activities * *Mark only one oval.*

	1	2	3	4	5	
VERY DISAGREE	☐	☐	☐	☐	☐	STRONGLY AGREE

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Chapter 3

Evaluating the Efficiency of schools in Bogotá and Cundinamarca: a metafrontier analysis

Juan Carlos Morales Piñero[1]

Abstract

The evaluation of educational efficiency has had a long research tradition identifying determinants in academic performance. This study seeks to determine to what extent the management carried out by the schools to achieve their academic objectives is conditioned by the sector to which they belong, the socioeconomic level of their students, and the technological pieces of equipment. For this purpose, a meta-border analysis with six models is used, applying data envelopment analysis to a population made up of 1.421 schools in Bogotá and Cundinamarca for 2016. The descriptive analysis shows that students by government schools presenting the Saber 11 Test are, on average, 2,4 times reported

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by non-government schools. The results obtained for the meta-border indicate a general inefficiency level of 16,32%. Inefficiency is reduced to 14,44% when comparing the sector to which the schools belong. Finally, when the sector and the socioeconomic level to which the schools belong are considered, the inefficiency of schools is reduced to 13,24%. The schools that benefited most from this segregation were the government schools, for which it was possible to determine that up to 30% of their inefficiency is explained by the sector and the socioeconomic level to which they belong. Likewise, it was found that government schools have better computer equipment and therefore are more sensitive to this variable. This leads us to deduce that the government schools would be giving little use to this equipment.

Keywords
Efficiency, meta-border, DEA, Secondary education.

Introduction

Studies on secondary education in Colombia have focused on analyzing educational quality, as evidenced by the numerous papers that discuss aspects related to it (Barrera, Maldonado & Rodríguez, 2012; Delgado, 2014; Loaiza & Hincapié, 2016; Marín, Riquett, Cecilia, Romero & Paredes, 2017; Marly, Jiménez & Jaramillo, 2012). However, aspects such as school management and efficiency have not received the same attention from the specialized academic community. Agasisti (2017), although in a study on higher education, highlights the importance of institutions offering greater capacity for educational services with the available resources. This premise has become relevant lately because public budgets are gradually decreasing, and it has had repercussions in the education sector. In a study, Salazar (2014) has already shown that Colombia could improve secondary education results from 6 to 10% without increasing expenditures.

Internationally, educational efficiency evaluation is long-standing, and there have been a significant number of successful academic articles (Witte & López, 2017). However, the literature available in Scopus, ScienceDirect, and Scielo focusing on studies that analyze schools' efficiency in Colombia is limited to Iregui et al. (2007) and Vélez & Psacharopoulos (1987). Only the study by Iregui et al. (2007) performs an analysis of school efficiency, using a Cobb-Douglas production function. This type of

stochastic methodology is not highly recommended to analyze the efficiency in the educational field because it is very restrictive in the assumptions that it establishes, as stated by Seijas (2004), thus increasing the use of non-parametric methodologies such as Data Envelope Analysis (DEA). Specifically, in the field of secondary education, the studies by Borge & Naper (2006), Chlebounová (2019), Muñoz & Queupil (2016), Podinovski, Ismail, Bouzdine & Zhang (2014) can be highlighted, all of which use the DEA methodologies to evaluate efficiency.

To what extent does the efficiency of schools depend on their management? Iregui, Melo & Ramos (2007) indicate that the variables related to the schools' infrastructure and the students' socioeconomic environment have a positive and significant impact on their academic performance. The authors also noted that the sector which the school belongs to also influences the results. In this same sense, Marly et al. (2012) conclude that only 11% of the test results' variations are due to individual factors. Equivalent findings have been corroborated in the study presented in the second chapter of this book.

With these approaches as precedents, this study tries to determine the extent to which the schools carry out to reach their proposed academic objectives determined by the sector to which it belongs, the socioeconomic status of its students, and the technological endowment. To this end, a metafrontier analysis was carried out, applying data envelopment analysis.

Methodology

The technique used for this part of the study was data envelopment analysis (DEA), a non-parametric technique based on linear programming that determines the efficiency of a group that executes similar activities using the efficiency frontier and classifying it according to its efficiency compared to another equivalent group.

This idea is based on recognizing schools as organizations that use a set of resources to obtain a series of outputs (learning outcomes) which are the product of the combination of various inputs (resources used for teaching), thus making it possible for schools to be considered as productive units (Decision Making Unit or DMU) that manage resources to obtain certain learning outcomes. Schools are conceived in this way to identify the

DMUs that produce the highest levels of outputs using the lowest levels of inputs and thus properly use data envelopment analysis.

However, this study proposes the use of DEA understood differently as it is typically employed, since, in addition to considering the existence of outputs to be maximized, it contemplates the existence of undesirable outputs to be minimized simultaneously (Chung, Färe & Grosskopf, 1997). This perspective has already been widely applied in various sectors. Such is the case of the study by Sueyoshi & Goto (2010), who used a DEA model that included the maximization of the energy generated by various plants seeking to minimize CO2 emissions. Similarly, Watanabe & Tanaka (2007) evaluated the efficiency of the Chinese industry using an output-oriented directional distance function by comparing models that included undesirable outputs with those that did not include them. A comparison between the two measures revealed that efficiency levels are biased if only desirable production is considered. Thus, they concluded that omitting unwanted production tends to overestimate efficiency levels.

When multiple inputs are used to produce multiple outputs, Shephard's distance functions (1953, 1970) provide a functional characterization of the structure of production technology and are also closely linked to technical efficiency measures, also playing an important role in the theory of duality.

It is a productive process, with a given T technology, which transforms N inputs $x \in R^N$ into M outputs and $\in R^M_+$ y $b \in R^H_+$ unwanted outputs for "*k*" DMUs. The process can be represented as follows:

$$P_x = \{(y, b) \mid x \text{ can produce } (y, b)\}$$

Assuming that this set of production possibilities satisfies the classic axioms (Färe, Grosskopf & Pasurka, 2007), it is possible to define a distance function for the process, capable of measuring equiproportional movements of the productive combinations of this set to reach the limit offered by T technology (Dios & Martínez, 2010). This way, the efficiency of any of the corresponding units in P_x can be measured through the following directional distance function (DDF) (Luenberger, 1992; Oh, 2010):

$$D(x, y, b) = \max(\beta \mid (y + \beta g_y, b - \beta g_b))$$

The previous DDF determines the maximum increase and reduction achievable by β in both the desirable and undesirable outputs, respectively, on the vector g=(gy, gb) which defines the desirable directions for the improvement of both types of results. In accordance with Giménez, Prieto, Prior & Tortosa (2019), this study uses the vector of M + H components g = (y, b) as suggested by Chung et al. (1997) and Oh (2010).

Population and sample

The population under study corresponds to the schools of Cundinamarca and Bogotá D.C. who have reported the participation of their students in the Saber 11 tests of 2016. The 2016 population was originally made up of 1.937 schools that met these characteristics, according to the ICFES databases, of which 11 schools that did not report information for the variables NSE (socioeconomic status), 44 schools belonging to the NSE 1 and 408 schools belonging to the NSE 4 were excluded, because the sample was biased towards the sector (government in case NSE 1 and non-government in case 4). Finally, 55 schools that did not report information for the Total enrolled variable were excluded.

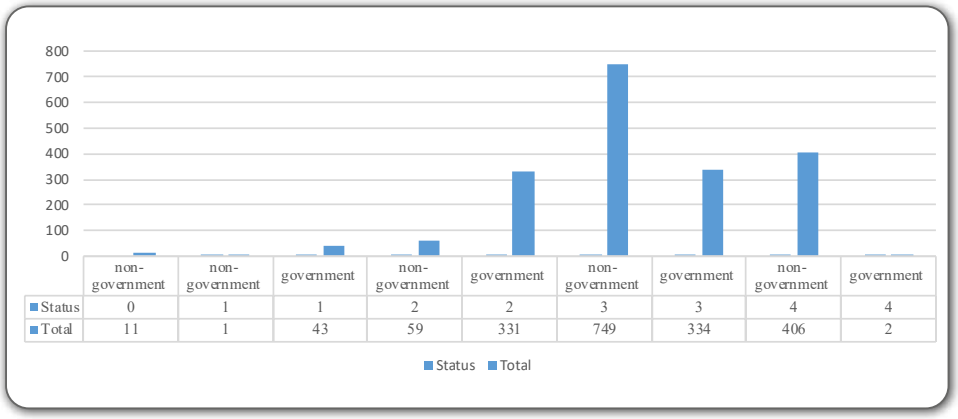

Figure 3.1. Distribution of schools by sector and NSE. The population was made up of 1.421 government and non-government schools belonging to socioeconomic status 2 and 3.

Variables

The variables used to perform the data envelope analysis are shown in table 3.1.

Table 3.1
Variables of the study

Name	Example	Description	Sources
Name of the institution	Example: INEM Francisco de Paula Santander.	Name of the headquarters where the teacher works	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
Code DANE	Example: 317380000942	DANE Code of the Institution. It was used as the unit of analysis identifier.	Ministry of Education https://sineb.mineducacion.gov.co/bcol/app
Average Pun_Global	Example: 252,37	Average calculated based on the total score obtained by those evaluated by the institution.	Data base ICFES 2016.
Attendants	Example: 87	Counting the number of students presenting the Saber 11 test in each institution.	Data base ICFES 2016.
Attendants x Average Pun_Global	Example: 2450	Variable calculated to measure the importance of the results of the Saber 11 tests according to the coverage by each institution.	Own calculation
Std. dev. Pun_Global	Example: 52,37	Standard deviation calculated based on the total score obtained by those evaluated by the institution.	Own calculation
Attendants x Std. dev. Pun_Global	Example: 1450,5	Variable calculated to measure the dispersion of the results of the Saber 11 tests according to the coverage for each institution.	Own calculation
NSE_	Example: 2 Values: 4 1 2 3 4	Variable defined by the ICFES to characterize the school based on various socioeconomic variables of its students. Level 1 presents characteristics such as the absence of a computer and internet in the homes of its students.	Data base ICFES 2016.

Name	Example	Description	Sources
Sector	Example: non-government Values: 2 non-government = 0 government = 1	Nature of the educational institution, whether public (governmental) or private (non-governmental).	Data base ICFES 2016.
Total teachers	Example: 27	Number of teachers working in the institution	Data base ICFES 2016.
Total equipment	Example: 97	Indicates the installed capacity in the school's technological infrastructure: computers, tablets, laptops.	Data base ICFES 2016.
Total Enrolled	Example: 257	Number of students enrolled in the school at all levels.	Data base ICFES 2016.
Category	Example: A Values: 6 A+ A B C D N/A	It corresponds to the categorization granted by the ICFES to the school based on the performance of its students. The A + category is the best a school can achieve. N/A indicates that the school was not categorized.	Data base ICFES 2016.

The following variables were defined to build the efficiency indices of the different schools (see Figure 3.2):

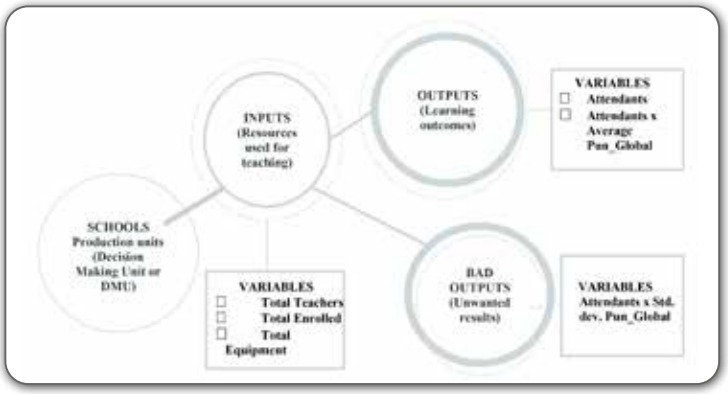

Figure 3.2. Variables of the study

Metafrontier of the study

Metafrontieranalysis is a methodology that allows comparing units that use different technologies. The traditional DEA model considers groups to be homogeneous, that is, it assumes that there are no variables present in one group of observations and not in another. However, if heterogeneous groups problems arise, methods of resolution through metafrontiers should be considered (O'Donnell, Rao & Battese, 2008).

To explain this idea in an intuitive way, suppose there is a group of DMUs for which a DEA analysis is performed assuming it is a homogeneous group. In this case, the results shown in Figure 3.3 indicate that only unit P would be efficient. If a border analysis is built by separating the analysis into two non-homogeneous groups, the *Gf* border will be obtained, where the efficient units are located. This results in two efficient units O and NO. If the K1 observation is used as an example, it could be said that the distance between Q1 and P would indicate the part of the inefficiency that would be explained by belonging to one of these groups.

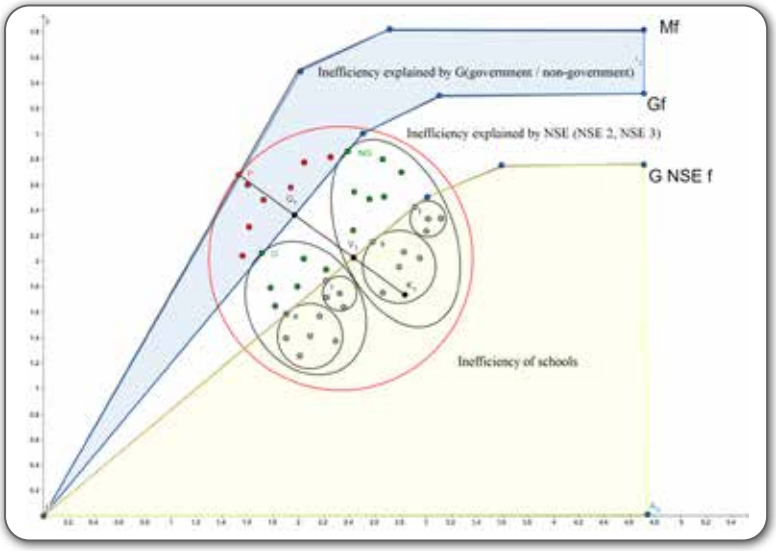

Figure 3.3. Metafrontiers by sector (G) and socioeconomic status (NSE). If a new frontier is built to highlight differences within the O and NO groups, it results in the G NSE f frontier. In this case, it turns out that the units e, r, s and t are in the efficient frontier, since the comparison was made in a more equitable way. In this case, the K1

observation could be complimented with the fact that the distance from V1 to Q1 would indicate the part of the inefficiency that would be explained by belonging to the NSE group. The rest would be the inefficiency of the K1 unit.

For this study, six models constructed as metafrontiers that allow a comparative analysis of the levels of inefficiency obtained by schools were proposed. In figure 3.4 are the models presented:

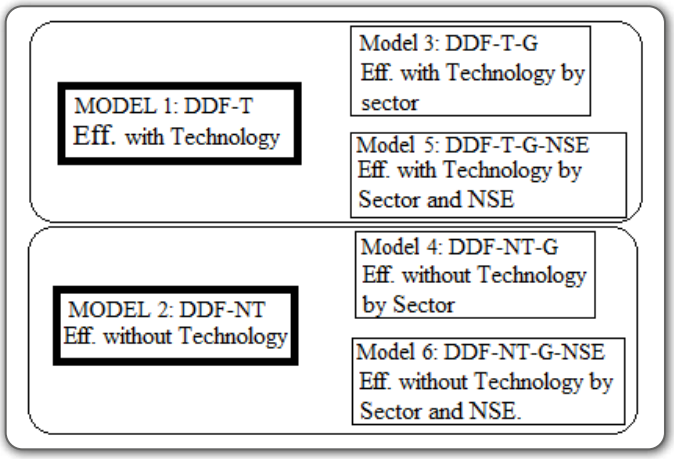

Figure 3.4. Metafrontiers defined for the study

Model 1 evaluates the level of inefficiency of schools based on the following parameters:

Output variables: Attendants and Attendants x Average Pun_Global

Unwanted output variable (bad output): Attendants x Std. dev. Pun_Global

Input variable: Total teachers; Total enrollment; and Total equipment.

Orientation: Outputs

Variable returns to scale

Model 2 evaluates the level of inefficiency of schools based on the parameters described above, assigning the value of 1 to the variable "Total equipment" for all schools. In this way, the effect of this variable in the

model is eliminated without generating an imbalance that prevents the comparison of metafrontiers.

Model 3 evaluates the level of inefficiency of schools based on the parameters described for model 1, performing the calculation separately for government and non-government schools. This allows the levels of inefficiency of the schools to be calculated with the DMUs belonging to the group as a point of comparison.

Model 4 evaluates the level of inefficiency of schools based on the parameters described for model 3, performing the calculation separately for government and non-government schools. However, the variable "Total equipment" is assigned the value of 1 for all schools.

Model 5 evaluates the level of inefficiency of schools based on the parameters described for model 3, performing the calculation separately for government and non-government schools. Likewise, for each group, the calculation is made considering the Socioeconomic status reported for the school, separating the comparison for the NSE 2 and NSE 3. This allows the groups to be compared under more equitable conditions.

Finally, model 6 evaluates the level of inefficiency of the schools based on the parameters described for model 5, performing the calculation separately for government and non-government schools and considering the school's reported socioeconomic status, separating the comparison for NSE 2 and NSE 3. However, the variable "Total equipment" is assigned the value of 1 for all schools.

The R Studio software was used to calculate the DEA model.

Results

Descriptive statistics and preliminary analyzes were performed with the SPSS software. The study focused on schools from socioeconomic status 2 and 3, to not bias the study. The preliminary analysis of the information shows that non-government schools have little presence in socioeconomic status 2 (6,42%) of which 58% are not categorized. In the case of socioeconomic status 3, it is observed that the population is well distributed. It is also observed that uncategorized schools are mainly non-government schools.

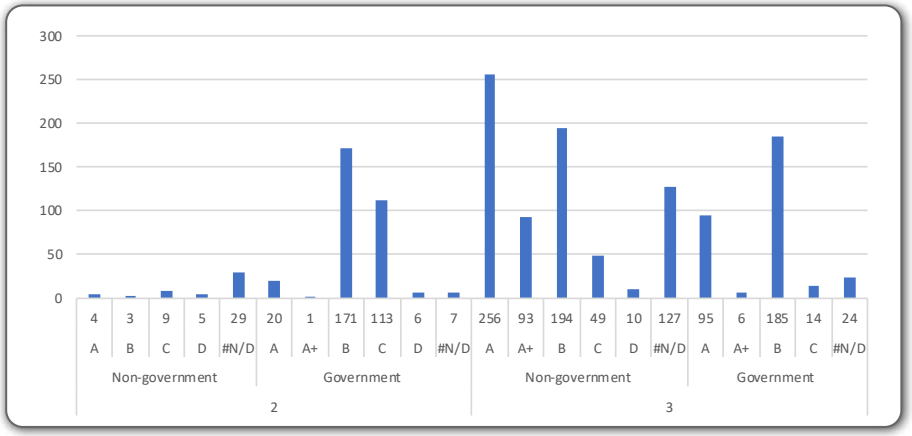

Figure 3.5. Distribution of schools according to ICFES category, sector and socioeconomic status. The number of students from government schools that present the Saber 11 Test exceeds by 2,4 times those from non-government schools (45 students per school). Likewise, it is observed that the dispersion of the data is much higher for non-government schools (46,99 students), even exceeding the average value of students per school (45 students). Looking at the results of the Saber 11 tests, they are slightly better for private (273) compared to public school (262,01). In addition, there is no significant dispersion in the results by sector.

To compare these data taking into account the impact (coverage) that these results have on the student population, the variable "Average Student of attendees x Saber 11 score" was constructed, which shows that the imbalance presented by the data by sector suggests that the comparison should be made separating the government and non-government sector.

Table 2
Descriptive statistic

VAR	Sector	Non-government	Government
01	Average Attendants	45	109,54
	Std. dev. Attendants	46,99	81,73
	Average Pun_Global	273	262,01
	Std. dev. Pun_Global	34	36,93
02	Average Attendants x Average Pun_Global	12.207	28.980,13

VAR	Sector	Non-government	Government
B1	Average Attendants x Std. dev. Pun_Global	1573	4100
I1	Average Total teachers	22,05	51,13
	Std. dev. Total Teachers	16,95	40,21
I2	Average Total Enrollment	465,78	1.228,34
	Std. dev. Total Enrolled	432,43	951,58
13	Average Total equipment	40,44	127,17
	Std. dev. Total equipment	38,79	155,60

Analyzing the inputs that the schools have to operate, it can be seen that there are no significant differences between government and non-government schools. Officials operate with a rate of 24 students per teacher and 9,67 students per computer equipment, while Non-government schools have an average of 21 students per teacher and 11 students per computer team. It is striking that the data has high dispersion, as evidenced by the values of the standard deviation.

Delving into the analysis of the results obtained by the models proposed in the metafrontiers, for model 1 the schools have a level of inefficiency of 16,32%. By removing the technological equipment from the input variables, the average level of inefficiency increases to 18,17%. However, considering that previous studies showed that the sector and the socioeconomic status were relevant variables that explain the variation in the results of the tests, differentiated models were proposed for these two variables. In this sense, models 3 (with computer equipment) and 4 (without computer equipment) show that the inefficiency of schools is reduced to 14,44% and 15,85% respectively when making the comparison by sector to which it belongs the school. Finally, models 5 and 6 evaluate the inefficiency of schools considering the sector and the socioeconomic level to which it belongs. The results indicate that when making the comparison considering these characteristics, the levels of inefficiency of the schools are reduced, even more, reaching 13,24% 8 with computer equipment and 14,72% without computer equipment. Likewise, it is observed that in all the models

the inefficiency of the schools increases significantly when removing the variable that technological equipment.

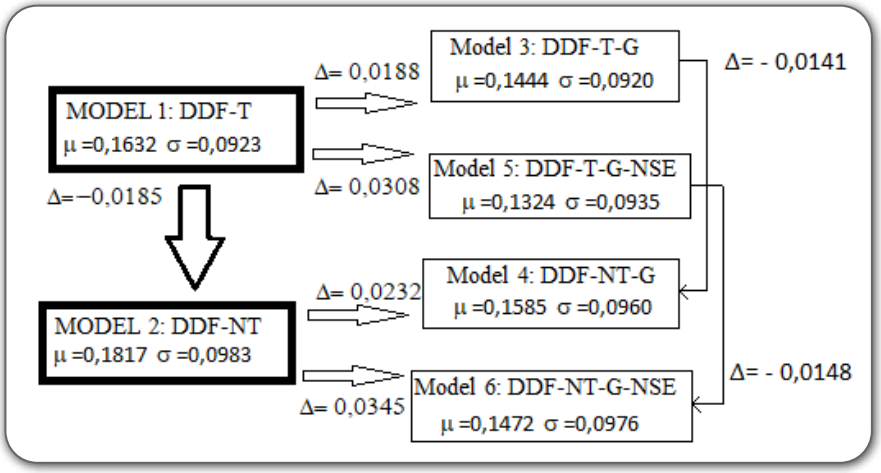

Figure 3.6. Results of the metafrontier

To analyze the results of the models in more detail, the inefficiencies of the schools were compared according to the sector which they belong to for each of the models. The results show that in all cases the schools belonging to the non-government sector obtain significantly higher levels of inefficiency than government schools. It is also observed that segregation by sector and by socioeconomic status does not significantly affect non-government schools, maintaining their levels of inefficiency in values above 17%. It is also observed that non-government schools show greater dispersion in levels of inefficiency, showing important differences between schools in the same group. Government schools show that, as their performance is evaluated considering the sector and the socioeconomic status as differentiating characteristics, their levels of inefficiency are significantly reduced, maintaining a lower dispersion in the data and a normal distribution in the data.

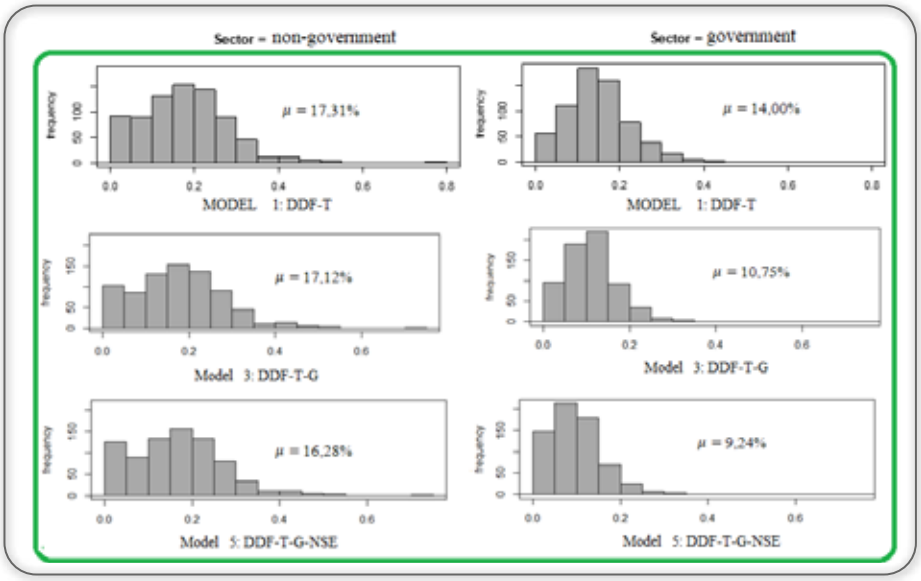

Figure 3.7. Metafrontiers by sector with technological equipment

By making the same comparison without considering the provision of computer equipment, government schools achieve a reduction of their inefficiency levels greater than 30%. In the same case, non-government schools only manage to reduce their levels of inefficiency by 8%.

These results indicate that, in the case of non-government schools, the comparison by groups segregated by sector, socioeconomic status and technological equipment only helps explain their levels of inefficiency around 8%. In the same case, government schools show that their levels of inefficiency are much lower and that these variables manage to explain their inefficiency by more than 30%, reaching values of 9,24%.

Once the evaluation of the efficiency of the schools was carried out considering differences by sector, NSE and provision of computer equipment, the correspondence of the results of the models with the categorization granted by ICFES was evaluated.

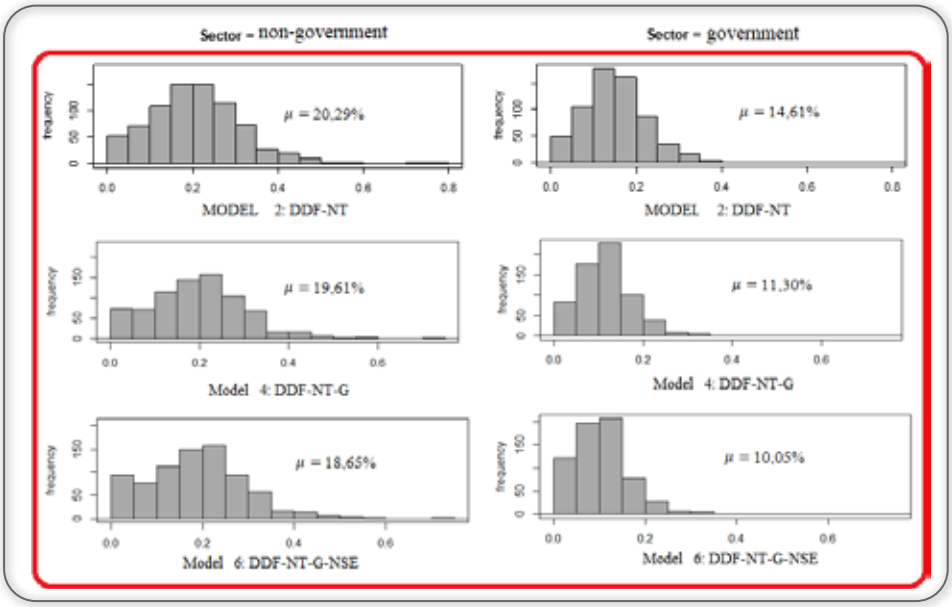

Figure 3.8. Metafrontiers by sector without computer equipment

Of the 1.421 schools analyzed, 13,2% failed to categorize for 2016, with non-government schools evidencing the highest proportion (83,42%). It can also be seen that the highest rankings are obtained by non-government schools, as they represent 93% of the schools categorized as A+ and 69,33% of the A schools. However, non-government schools also occupy the highest proportion of the lowest category (71,43%).

Focusing, then, on the schools that reach the efficient frontier in the different models, it can be observed that the results do not have a direct relationship with the categories established by the ICFES. Cases that attract the most attention are those of schools categorized as A+, since of the 100 schools that obtained this category, only 12 placed themselves on the efficient frontier. Another result that attracts special attention is category D schools: the 21 schools in this category are classified as inefficient in the case of the first four models, which is related to the categorization of ICFES. However, when evaluating its efficiency by segregating the comparison by sector and NSE, three schools manage to place themselves at the efficient frontier. This result indicates that these 21 DMUs have particularities that,

when evaluated in context, manage to locate three schools on the efficient frontier, thus recognizing the particularity of the schools.

Table 3.3
Efficiency results by category according to each model

					Efficient schools according to the model					
	Category of the schools				DDF-T	DDF-NT	DDF-T-G	DDF-NT- G	DDF-T-G-NSE	DDF-NT-G-NSE
	N°	%	Government %	Non-government %	N°	N°	N°	N°	N°	N°
N/A	187	13,2	16,6	83,42	16	3	22	15	33	25
A+	100	7,0	7,0	93,00	9	7	11	10	12	11
A	375	26,4	30,7	69,33	8	5	11	8	19	14
B	553	38,9	64,4	35,63	11	7	18	11	30	18
C	185	13,0	68,7	31,36	8	6	11	9	14	11
D	21	1,5	28,6	71,43	0	0	0	0	3	3
Total	**1421**	**100**			**52**	**28**	**73**	**53**	**111**	**82**

Table 3.4 shows the results of one of these three D category schools classified as efficient are analyzed in more detail. This is a government school with NSE 2 that is compared with 19 schools that fit these variables and share equivalent input levels.

The second case presented to analyze refers to one of the 11 A+ schools that manages to be located on the efficient frontier in the "DDF-NT-G-NSE" model. This is a non-government school with NSE 3. Therefore, it will only be compared to schools in the same group. The following table shows the results, observing that the comparison is made for a group of 46 schools, leaving one of them as a reference point. It is observed that this school operates with 38 teachers, 977 students enrolled and has 74 computers. With these resources it is possible to obtain an average score of 305 with a standard deviation of 26, sending 88 students to take the exam.

Table 3.4
Detailed analysis of efficiency for an efficient D school

	DMU	INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
1	325290002135	0	D	234	32	87	20350	2787	13	199	12
2	325754005595	0,008	D	243	32	61	14798	1976	10	221	56
3	311001110573	0,020	N/A	214	31	39	8337	1204	12	120	10
4	311001110271	0,021	N/A	229	33	71	16230	2373	10	210	21
5	311001105448	0,058	N/A	230	37	99	22815	3644	21	667	18
6	325183000663	0,040	D	218	33	48	10464	1587	13	140	15
7	325126048170	0,042	D	219	34	70	15311	2410	14	223	50
8	111001028207	0,056	N/A	236	32	32	7537	1032	151	2602	123
9	311001017531	0,084	N/A	233	27	14	3263	372	12	72	126
10	325754003428	0,087	N/A	245	36	46	11291	1675	23	703	26
11	311001093962	0,096	N/A	229	31	19	4350	594	9	107	16
12	325214047523	0,099	N/A	242	34	26	6280	884	16	160	19
13	311001109001	0,102	N/A	236	32	21	4965	682	10	193	27
14	311001109419	0,112	N/A	231	39	50	11540	1936	11	923	13
15	325758002922	0,114	D	233	39	46	10730	1787	10	213	33
16	325754001221	0,116	N/A	250	30	15	3752	446	12	395	24
17	311001089710	0,132	B	256	37	28	7177	1047	12	291	33
18	311001079862	0,135	B	258	33	17	4394	558	14	224	25
19	311001091595	0,151	N/A	248	42	42	10406	1761	16	212	40
20	325290002167	0,162	N/A	237	34	16	3788	545	11	74	20
21	425843000631	0,177	A	270	39	19	5126	732	12	186	25

Note: DEA model creates small comparable groups under the established parameters. On this set of data, one of them is established as a reference, which is the one that has the best combination of results and then calculates the potential levels of improvement (inefficiency) that each school can achieve with respect to the point of comparison. In this case, the school that moves farther away from the efficient border has a potential for improvement of 16,17%.

Table 3.5
Detailed analysis of efficiency for an efficient A+ school

DMU		INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
1	311001003971	0	A+	305	26	88	26832	2264	38	977	74
2	311001033510	0,044	A	303	29	101	30566	2925	51	1358	69
3	311001079901	0,046	B	266	32	124	32964	3930	45	1211	95
4	311001004897	0,047	A	289	32	139	40111	4488	52	2046	320
5	311102001007	0,050	A	284	31	103	29208	3160	39	942	51
6	311102000124	0,063	A	293	29	90	26370	2622	48	1015	124
7	325754003312	0,068	A	276	33	127	35094	4137	58	1506	81
8	325754004238	0,084	A	278	33	110	30634	3667	45	2021	38
9	325754003410	0,085	A	269	34	132	35509	4538	56	1886	117
10	311001078734	0,086	A	291	33	131	38155	4367	70	1392	34
11	311001026513	0,092	A+	303	33	102	30867	3370	46	1193	173
12	325290000030	0,100	A+	303	34	112	33975	3811	54	1112	215
13	311001027188	0,104	A	297	33	89	26422	2959	37	840	122
14	311102001244	0,108	A+	300	31	85	25459	2675	50	1323	71
15	311001012598	0,110	N/A	296	35	109	32236	3860	44	969	92
16	325754005471	0,111	B	271	35	118	32032	4126	60	1507	80
17	325899000443	0,112	A+	311	33	88	27385	2930	44	791	105
18	311001093130	0,118	A	295	34	110	32470	3793	62	1344	139
19	311001091129	0,124	A	297	35	91	27008	3168	40	1217	115
20	311001027803	0,125	B	272	32	68	18517	2169	31	834	54
21	311001036900	0,129	B	266	37	109	28978	4077	40	1154	120
22	311001006130	0,133	A+	312	34	90	28112	3068	52	1301	105
23	311279000043	0,134	A+	327	31	60	19635	1873	35	935	57
24	311001090793	0,136	A	290	33	70	20320	2296	34	713	105
25	311001000531	0,136	A+	305	32	65	19822	2103	31	867	32
26	311001041873	0,142	A	290	40	140	40577	5564	56	1879	98
27	311001032637	0,148	B	269	37	103	27719	3807	54	1316	31
28	325260000019	0,152	B	272	35	74	20130	2591	34	1043	59
29	311001001707	0,154	A+	296	37	89	26381	3310	39	777	71
30	311001038368	0,157	B	259	36	95	24588	3436	58	1412	97
31	311001050317	0,158	A	283	37	97	27414	3617	52	1114	64
32	311001092907	0,159	A	284	39	106	30153	4082	52	1324	53
33	311102001287	0,160	B	293	39	133	39003	5170	81	2165	112

DMU		INEFFICIENCY	OTHER VARIABLES			OUTPUTS		BAD OUTPUTS	INPUTS		
	Code DANE	DDF-NT-G-NSE	Category	Average Pun_Global	Std. dev. Pun_Global	Attendants	Attendants x Average Pun_Global	Attendants x Std. dev. Pun_Global	Total teachers	Total Enrolled	Total equipment
34	311001075395	0,160	B	267	39	102	27280	3964	45	1220	63
35	325307000047	0,163	A+	306	36	80	24457	2856	45	733	59
36	311001043001	0,168	B	270	37	78	21039	2890	35	832	35
37	325754002961	0,174	B	268	37	74	19846	2748	33	1193	43
38	325754003592	0,177	B	272	36	69	18750	2475	35	948	62
39	311001006466	0,178	A	291	36	85	24728	3095	57	1251	44
40	111001000353	0,181	A	288	39	92	26541	3577	49	1047	118
41	325307000055	0,182	A	288	39	94	27040	3699	49	905	104
42	325286000149	0,190	A	283	36	67	18982	2435	36	978	45
43	311001020191	0,202	C	249	37	64	15955	2389	32	1119	60
44	311769000785	0,212	B	278	38	64	17822	2440	33	862	41
45	311001042977	0,227	B	260	39	63	16353	2486	32	594	28
46	311769004233	0,267	A	291	44	69	20096	3023	41	781	35

Note: results allow observing that these 45 schools have the potential of improving their results ranging from 4,4% to 26,7%. Likewise, it is observed that this school has comparable results with 9 A+ schools, 20 A schools, 14 B schools, 1 C school and an uncategorized school.

This leads to thinking about the need to project categorizations by segregating schools by those variables that have been decisive when explaining student performance.

Conclusions

Based on the effect of the sector and the socioeconomic status referred to in Chapter 2 of this book, the evaluation of the performance of the schools was carried out with the enveloping data analysis, separating the groups in metafrontiers according to socioeconomic status and sector. In this sense, the results allowed to verify that schools that had been placed in the lowest categories by the ICFES were classified as efficient schools. The opposite also occurred.

This difference occurs because when categorizing schools under a comparison matrix that assumes group homogeneity, which part of the expec-

ted achievement is conditioned by variables that are beyond their control and that do not make it comparable with another group is forgotten. In this regard, the comparison with the DEA through non-parametric borders poses a more equitable solution.

The schools that benefited most from this segregation were government schools. It was possible to determine that up to 30% of their inefficiency is due to the sector they belong to and to their socioeconomic status.

In this sense, this study allows to conclude that, depending on the condition of the institution which the students belong to, whether public or private, the results obtained in the Saber 11 tests will be different. Thus, a government school tends to have lower results than a private one if they are compared without considering their differences.

When evaluating the efficiency of the schools through the data envelopment analysis by segregating the analysis with and without technological equipment, it was observed that, in all cases, schools increased their inefficiency by not having this variable. Likewise, it was found that government schools are better equipped in computers and therefore are more sensitive to this variable. This corroborates the results obtained in the previous regression study and would indicate that government schools would be giving little use to this equipment.

This leads to a hypothesis for further studies regarding whether standardized tests would focus only on the domain of content, as well as regarding the need to advance in longitudinal studies that evaluate the change in time that would be obtained with an adequate integration of technology, pedagogy, and content in classrooms.

References

Agasisti, T. (2017). Management of Higher Education Institutions and the Evaluation of their Efficiency and Performance. *Tertiary Education and Management*, *23*(3), 187-190. doi: 10.1080/13583883.2017.1336250

Barrera-Osorio, F., Maldonado, D., y Rodríguez, C. (2012). Calidad de la educación básica y media en Colombia: Diagnóstico y propuestas. *Universidad Del Rosario. Escuela de Economía, Documentos*, (126), 1-74.

Borge, L.-E., y Naper, L. R. (2006). Efficiency Potential and Efficiency Variation in Norwegian Lower Secondary Schools. *FinanzArchiv*, *62*(2), 221. doi: 10.1628/001522106x120677

Chlebounová, D. (2019). Determination the efficiency of secondary schools in the Pardubice region. *Scientific papers of the University of Pardubice. Series D, 45*, 77-88.

Chung, Y. H., Färe, R., y Grosskopf, S. (1997). Productivity and Undesirable Outputs: A Directional Distance Function Approach. *Journal of Environmental Management*, *51*(3), 229-240. doi: 10.1006/JEMA.1997.0146

Delgado Barrera, M. (2014). *La educación básica y media en Colombia: retos en equidad y calidad*. Bogotá.

Dios Palomares, R., y Martínez Paz, J. M. (2010). Análisis de eficiencia de la industria oleícola desde un enfoque multioutput con distancias econométricas. *Revista de Estudios Empresariales. Segunda Época*, (1), 54-84.

Färe, R., Grosskopf, S., y Pasurka, C. A. (2007). Environmental production functions and environmental directional distance functions. *Energy*, *32*(7), 1055-1066. doi: 10.1016/J.ENERGY.2006.09.005

Giménez, V., Prieto, W., Prior, D., y Tortosa-Ausina, E. (2019). Evaluation of efficiency in Colombian hospitals: An analysis for the post-reform period. *Socio-Economic Planning Sciences*, *65*, 20-35. doi: 10.1016/j.seps.2018.02.002

Iregui, A., Melo, L., y Ramos, J. (2007). Análisis de eficiencia de la educación en Colombia. *Revista de Economía Del Rosario*, *10*(1), 21-41.

Loaiza Quintero, O. L., e Hincapié Vélez, D. (2016). Un estudio de las brechas municipales en calidad educativa en Colombia: 2000-2012. *Ensayos Sobre Política Económica*, *34*(79), 3-20. doi: 10.1016/j.espe.2016.01.001

Luenberger, D. G. (1992). New optimality principles for economic efficiency and equilibrium. *Journal of Optimization Theory and Applications*, *75*(2), 221-264. doi: 10.1007/BF00941466

Marín González, F., Riquett Escorcia, M., Cecilia Pinto, M., Romero Caballero, S., y Judith Paredes, A. (2017). Gestión participativa y calidad educativa en el contexto del Plan de mejoramiento institucional en escuelas colombianas. *Opción*, *33*(82), 344-365.

Marly, T., Jiménez, O., y Jaramillo, J. F. (2012). ¿Cuál es la brecha de la calidad educativa en Colombia en la educación media y en la superior? En ICFES (Ed.), *Estudios sobre calidad de la educación en Colombia* (pp. 67-98). Bogotá, Colombia: ICFES.

Munoz, D. A., y Queupil, J. P. (2016). Assessing the efficiency of secondary schools in Chile: a data envelopment analysis. *Quality Assurance in Education*, *24*(3), 306-328. doi: 10.1108/QAE-05-2015-0022

O'Donnell, C. J., Rao, D. S. P., y Battese, G. E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics*, *34*(2), 231-255. doi: 10.1007/s00181-007-0119-4

Oh, D. (2010). A global Malmquist-Luenberger productivity index. *Journal of Productivity Analysis*, *34*(3), 183-197. doi: 10.1007/s11123-010-0178-y

Podinovski, V. V., Ismail, I., Bouzdine-Chameeva, T., y Zhang, W. (2014). Combining the assumptions of variable and constant returns to scale in the efficiency evaluation of secondary schools. *European Journal of Operational Research*, *239*(2), 504-513. doi: 10.1016/j.ejor.2014.05.016

Salazar Cuéllar, A. F. (2014). La eficiencia del gasto público educativo en Latinoamérica y lecciones para Colombia. *Desarrollo y Sociedad*, (74), 19-67. doi: 10.13043/DYS.74.1

Seijas Díaz, A. (2004). *Evaluación de la eficiencia en la educación secundaria*. Coruña, España: Netbiblio.

Sueyoshi, T., y Goto, M. (2010). Should the US clean air act include CO2 emission control?: Examination by data envelopment analysis. *Energy Policy*, *38*(10), 5902-5911. doi: 10.1016/J.ENPOL.2010.05.044

Vélez, E., y Psacharopoulos, G. (1987). The external efficiency of diversified secondary schools in Colombia. *Economics of Education Review*, *6*(2), 99-110. doi: 10.1016/0272-7757(87)90044-6

Watanabe, M., y Tanaka, K. (2007). Efficiency analysis of Chinese industry: A directional distance function approach. *Energy Policy*, *35*(12), 6323-6331. doi: 10.1016/J.ENPOL.2007.07.013

Witte, K. De, y López-Torres, L. (2017). Efficiency in education: a review of literature and a way forward. *Journal of the Operational Research Society*, *68*(4), 339-363. doi: 10.1057/jors.2015.92

Chapter 4

ICTs and their impact on secondary education schools: Case studies in Bogotá and Cundinamarca

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Abstract

The following chapter presents the results of the ethnographic study in the research project called "Incidence of ICTs in the improvement of the Saber 11: an analysis based on the TPACK model", developed between the ICFES and the Sergio Arboleda University (Bogotá).

The study's objective was to learn about the pedagogical practices and teaching styles of teachers, the integration of ICTS into didactics, and the behavior of students in grades 10 and 11. The methodology was ethnographic, for which seven (7) secondary education institutions from the colleges of Bogotá and Cundinamarca were selected. Two teachers from each institution were selected, one with several years of experience and one with less. A discussion group was also carried out for each establishment, with students of these two teachers.

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The results confirm the importance of training in ICTs and that they have an impact on teaching practices, which are at the same time related to training and the proper integration of ICTs.

Keywords
ICTs, teaching-learning impact, media education, pedagogical practices

Introduction

Investigating about ICTs and their impacts on the Saber 11 tests and teaching practices leads to analyzing research, studies, and cases that account for how ICT-mediated teaching-learning processes are being carried out in high schools.

The integration of ICTs in the educational field has become a constant concern in recent years. As it is clear and obvious, education is taking part in the era of ICTs. Gamification, blended learning, virtual environments, and MOOCs are some examples. Contemporary teaching cannot be thought of without the incorporation of new technologies, as shown by various studies (Başak & Ayvaci, 2017; Liestol, Doksrod, Ledas & Rasmussen, 2012; Melo, Chávez, Indacochea & Núñez, 2017).

The integration of ICTs goes beyond the mere implementation of isolated techniques since it implies didactic constructions and developments in favor of learning processes, which forces teachers to be updated and trained according to the needs of the environments. These dynamics will allow students to energize their learning and generate vigorous transformations for education (Hernandez, 2017).

When asking if the integration of ICTs has transformed teaching practices, Cortés, Vargas & Neira (2017) found that their incorporation has been a challenge since it implies updating and learning to use these tools. Others affirmed that continuous use would be essential and that the integration of ICTs allows greater participation among students and, in any case, benefits them more as it involves collaborative work.

Therefore, secondary education institutions must meet these challenges with comprehensive and transversal training plans, both for teachers and

students, since the processes must include feedback dynamics to ensure the proper management of technological tools, which could be a valuable way to improve learning.

Thus, education has not been an isolated research topic. On the contrary, it is an aspect of great relevance for an inquiry which has allowed the appropriation of different teaching methods and projects in favor of its continuous improvement. In addition to this, the importance of the inclusion of technologies and their management demands training, dynamic and active processes in which technologies are included but which, at the same time, should be guaranteed the required management. In this sense, it is appropriate to investigate the impact of ICTs on teaching practices of secondary education in Bogotá and Cundinamarca?

State of the art

When reviewing the impact of ICTs on teachers' practices of grades 10 and 11, as well as the contexts and experiences where they have been developed, both national and international studies are found. These studies range from diagnoses of the use of ICTs in government schools, the integration of ICTs as a means of teaching foreign languages, and research evaluating ICTs in rural learning environments.

On the other hand, other researches related to the importance of using ICTs as learning tools in elementary and middle school are highlighted as well as the importance of integrating ICTs in secondary education and the use of technologies.

Likewise, a study on the planning and incorporation of graduates for teachers' training in the pedagogical use of ICTs and the implementation of devices and digital material as a means of communication between teacher-student stands out.

It was essential to review these studies so that the experiences and fieldwork addressed were allowed to explore and contribute to the present study's consolidation.

National context

From the analysis presented by Castellar (2011), the importance of using ICTs and their potential once integrated into the classroom to favor learning processes was observed. For this study, a survey y was prepared and applied to 312 students from secondary government institutions of the Soledad Atlántico Municipality.

The instrument was composed of seven questions, both open and closed, which aimed to establish an overview of the potential perceived by the students through two items: the first linked the benefits and usefulness of ICTs in their training, while the second was associated with the skills that can be improved through the integration of ICTs.

However, according to the results presented, it can be observed that students demand change in the teaching-learning processes since, as demonstrated in the results, the arrival of technology demands to break the distance between traditional ways and the inclusion of technology. Simultaneously, Castellar mentions the teacher's importance as a guide and counselor of the student, since the integration of ICTs, due to inexperiences, can be difficult.

In another study by Cuadros, Valencia & Valencia (2012), technologies are considered tools that improve the quality of socialization and, of course, the teaching-learning processes. The authors focus on the fact that ICTs, as tools, favor all areas of people'speople's activity, so it becomes essential for education to have access to various resources.

Likewise, to strengthen social relations, a series of obstacles were evident in the rural context, among which physical and digital resources were detected, as well as the need to train people in these areas on issues that are consistent with their context'scontext's needs and the necessary resources that favor the processes and the application of the theory.

It is also mentioned that, without overcoming these difficulties and covering the needs of rural areas, spaces that include ICTs cannot be created to be able to educate the rural community in terms of technology. This is because inequality in access to knowledge and information generates a

delay in the development of these areas of the country. So, although the State creates policies that allow technology to be incorporated into rural areas, these policies must also go hand in hand with connection inputs, training programs, and the development of digital skills that allow them to meet their needs and processes in the social context in which they are.

In the case of Peláez (2015), it is evidenced that, currently, ICTs play an important role in peoples people's daily lives, so they seek to integrate them to give them a significant value in education. Thus, using methodologies, both conventional and unconventional, it is intended to teach children in grade 5 from the educational institution Villa Santana on issues of fractional numbers, in order to assess the impact of technological and digital integration into the educational process.

To start the research, a pre-test was carried out, which aimed to identify the starting point. The course was then divided into two subgroups and, subsequently, a post-test was done to make the respective comparisons. From the evidence and analysis carried out, it can be concluded that, when presented as tools and work inputs, ICTs impact the teaching-learning process significantly, as the academic performance of the students who participated in this sample improved. On the other hand, this type of innovation in education generates interest and motivation in the student, so teachers increasingly need to appropriate and train in technological management issues.

The study of Córdoba Castrillón (2017) is, thus, necessary. It intends to demonstrate why students should be involved in creating policies and in the measures that ICTs incorporate in the learning process and the educational environment. The research has a quantitative non-experimental design approach of a descriptive nature, which included a survey for students from grades 6 to 11 from the Metropolitan area. Students were selected conveniently by the institution. The instrument was applied in eight public educational institutions, from the municipalities of Medellín, Bello, and Girardot.

The instrument aimed to collect information about students'students' tastes and preferences about ICTs as learning tools. The survey was replicated to 200 students, of which 48% were women, and 52% were men, while 75% belonged to primary and 26% to secondary school. The results showed

that the thinking of the secondary and essential student has changed with the arrival of ICTs, since, despite this, it is still believed that they do not belong to a digital era and that, also, the use of such devices is not suitable for their educational process. Although the study highlights that there is a change, it emphasizes that measures must be taken to address this fact. That is why the student's taste and preferences should be incorporated, for they favor change and guide the actions planned by the Ministry of Education to improve the quality of education in Colombia.

This study focuses on the need to know these types of tools, what they are, what they are for, and how they impact student learning as the first step for a more educated Colombia in 2025.

To that extent, to have and to complement a national vision, the study by González, Cardona, & Montoya (2017) is presented. The authors affirm that currently, there are demands for teachers to be trained in using this technology to integrate them properly in their teaching practices. Because of this policy, some educational institutions have created a network of teachers that aims to train in the management of technological and digital devices to improve their performance as a teacher. The members belonging to this network were being trained in theories, designs, and media created during the first two months.

In this study, regarding teaching the English language integrating ICTs, the authors used a qualitative methodology. The case study was worked on as a strategy to evaluate the practices, interactions, and attitudes in the workspace and the duration of the training. The instruments used for measurement were a survey and an interview. The interview was recorded and transcribed by the practice group community (CP). The context of the interview revolved around the motivations of the participants, knowledge of the way in which ICTs were used for their education, and the time each one spent to reach their objective. The interview, conducted by an external researcher, was intended to have each member narrate their experience and reflection after being trained in the use of it.

It should be mentioned that the results are allowed to be classified under three fundamental axes: collaborative learning, professional devel-

opment, and difficulties in integration. The results allow us to conclude that thanks to integrating ICTs, space is generated where collaborative work is promoted. On the other hand, it is evident that the structure of the community of practice and its training favors the professional development processes of each member by providing them with didactic, technological, and disciplinary knowledge for their teaching practices.

In this sense, it is perceived that, in fact, teachers are trained in ICTs and that there are serious projects aimed to do so. Nevertheless, it is also evident that when these are included, they aim towards central learning objectives that also transform the efforts for the inclusion of these tools, bring benefits that contribute to the educational quality of the institutions, and reflect themselves in the country's development.

International context

Initially, the work of Fernández, Fernández, & Rodríguez (2018), who analyzed the process of integration and pedagogical use of ICTs in educational centers of Madrid, is highlighted. In this study, the lack of techno-pedagogical preparation by teachers is striking, that is, the poor preparation in technology of the educators themselves and their lack of interest to integrate it into the classroom as a pedagogical tool. To solve this dilemma, UNESCO proposed a series of competences for teacher training and preparation in technology with the main objective of analyzing the fundamentals and main needs of this topic through an instrument that allows assessing the situation. A study by Fernández et al. (2018) took as a sample a population of teachers in the community of Madrid who taught primary and secondary levels. They were divided into two categories: a group with experience between 0 and 5 years and another with more.

For the data collection, a questionnaire with a total of 63 items was created. Curriculum, planning, evaluation, pedagogy and didactics including ICTs and skills characteristics in continuous training were evaluated. To analyze this data, three types of profiles were established: (1) Basic notions in ICTs, (2) Expanding knowledge and (3) Knowledge generation.

The results allowed to conclude that there are important factors that should be highlighted and studied in greater depth, such as the integration

of ICTs in education in Madrid. On the other hand, the study found that the profile of teachers tends to be within the first two categories, which suggests that the educational model only fits technological use but does not go beyond instruction.

In this regard, Domínguez, Hernández & Chica (2018) analyzed the incorporation of technology in the classroom in Spain. Already by 2003, the country had started conversations in order to bring computers to all educational centers, which was fulfilled by the beginning of 2011. However, they faced the same problem as in other parts of the world: What to do with these pieces of equipment? Is the teaching staff fully trained to use them?

Due to this, they generated a simple tool to assess the impact of ICTs on both students and teachers. The categories were: training, ICT inclusion spaces, ICT management, vision of ICT use and educational activities where ICTs are incorporated. After having applied the instrument to students and teachers, it was concluded that quality prevails above updating tools since using them does not guarantee the understanding of their function. It was also concluded that there is a great agreement between students and teachers regarding the use of the tool since it can be helpful to use ICTs. However, students create other spaces where they are allowed to acquire these digital skills on their own. Thus, teachers must act, since they must be responsible for the orientation and updating of their own knowledge to be more prepared than their student and thus improve the quality of education (Domínguez et al., 2018).

These aspects were evidenced in the advanced fieldwork, since the students, in addition to feeling motivated when the methodologies are included, also take advantage of them to expand their knowledge or review the processes that have not been assimilated.

Hernández & Sosa (2016) analyzed the vision of a technology specialist advisor on the process of implementing ICTs in educational centers and their impact on learning. The State and the deans of different schools have invested in education, which supports the updating of educational tools. However, it seems that there is a problem with teaching, since there

is evidence of a lack of training to use these technological devices. From this point of view, the authors created a project entitled "Technology at the service of people (TSP)" which sought to create a policy of advice and support to schools through 14 teacher centers (CEP) to collect data on the impact that ICTs have on the teaching-learning process in grades 5 and 6 of the Canarian community.

Regarding this initiative, 18 free participation interviews were conducted, for which an instrument was created that would evaluate six aspects that the ICTs approach brings: connectivity, software suitability, hardware quality in terms of its obsolescence and its improvement, endowment in educational institutions and the differences that the use of ICTs have in primary and secondary schools. However, when collecting survey data, some analyses showed that innovative practices tend to use ICTs to link the use of devices such as cell phones and tablets, which in turn are implemented to make use of virtual teaching platforms and blogs. On the other hand, this change has allowed creating spaces for the teaching of robotics that allow solving problems within the educational centers. Similarly, there are perceptions about the use of ICTs by teachers, which has led to a non-decisive impact since there is no practice or general use. The didactic process in learning stands out, although the class is not planned since the inclusion of technologies. Something significant is that it is possible to incorporate the model and traditional planning as support (Hernández & Sosa, 2016).

The study by Briceño & Castellanos (2016) on teacher training diplomas in the pedagogical use of ICTs stands out. With the incorporation of these, the authors seek to provide a solution to the training, where clear ideas of how the teacher can approach the use of ICTs in the classroom are established, such as scientific competences where technology can be included as a means or education tool. The implementation of devices and digital material as a means of communication between teacher-student allows to mediate and facilitate the information and resources that students need for their learning process. However, a commitment must be made between both roles to promote the inclusion and proper use of technology. Based on these ideas, four models of graduates are created where three

different types of competencies are sought to be developed: explorer, integrator and innovator; which are the basis for executing an individual ICT project where they include a teaching model and can participate in a congress that finances this type of work.

After that, an overview was made of the diploma models where each one has three modules. The first one is where the theory is received and begins with the practical work of familiarizing the teacher-student with ICTs. In the second module, this knowledge must be projected through a project and, finally, a third space where feedback is given, run, shown and generated to classmates. To conclude, the implementation of ICTs manages to transform the physical and social gaps that are generated in the need of attention of each student (teacher). This can happen as long as the basics of this project are completed; that is, if the group that is trained, if there is a curriculum with clear goals, if there are enough pieces of equipment for all and if there is stimulus for the student (teacher) to continue. On the other hand, the objective of this project is to train based on the human needs that the arrival of ICTs has brought, a need that has allowed training and strengthening the teaching practice in ICTs.

The study by Acosta & Hernández (2014), who analyze the use of collaborative learning methodologies mediated by ICTs in secondary education, is also highlighted. This scenario was designed according to the demands of education to maintain the leadership in which society is located and to meet the needs of the diverse learning rhythms of students. Through this project, they seek, through collaborative learning and the inclusion of ICTs, to instruct teachers under the proposed methodology to improve communication with students and thus provide greater quality in the academic environment. For this, collaborative learning based on ICTs was evaluated using teachers from ESO centers, which work 4th and 5th levels of ICTs in the provinces of Salamanca and Zamora. To support this research, the student's vision regarding the methodology, tools used and the affectivity of it, was taken into account.The type of methodology was mixed because the qualitative analysis is implemented to evaluate teaching practice and progress in the academic environment after including ICTs. While quantitatively, independent and dependent variables of technological tools were tested out, teacher training and other variables that were part

of the object of study were analyzed and verified. Regarding data collection different instruments were applied such as interviews, questionnaires, follow-up sheets, observations, and records, which were previously prepared to increase the reliability of the results. The context of the evaluation practices and of how students learn under the influence of collaborative learning will be analyzed.

Finally, it was sought that the problems raised within the project such as: dependency system, design activity, group adaptation, teacher training, institutional support and communication problems do not become an obstacle to delay the distance between teachers and ICTs in the classroom, which makes this the problem to solve. It is also intended to generate, as an added value, a positive attitude and increase levels of motivation in the student through the management of ICTs in this learning model (Acosta & Hernández, 2014).

Accordingly, the research of Maldonado, Ruiz, Gómez, & Soto (2019) is analyzed, who in their study analyzed the use of ICTs in bilingual secondary education in public schools in Andalusia. In this case, the authors intend to analyze the real use of ICTs by teachers in non-linguistic areas included in the bilingual project in Andalusia, where the relationship between teachers and the use of ICTs can be evidenced to optimize and improve the quality in their use.

As a basis, the study takes the vision of the business management specialist McClelland, who uses the meaning of competence, instead of competent, to refer to the student's ability to increase their job performance, which includes social skills. It arises from the combination of practical skills, knowledge, motivation, ethical values, attitudes, emotions and other behavioral components that are structured together to achieve effective communication.

To carry out the proposed objectives, a survey was created that seeks, through the collection of information, to describe the conditions of the object of study, identify comparative patterns and determine the existing relationships within the context to be studied. The survey was designed with the purpose of grouping the data into two different groups: students

and teachers. The first questions are aimed at being sociodemographic, the questions can be open, multiple-choice, and Likert type with answers that would meet criteria to be categorized. Continuing with the method of data collection, nine (9) samples were obtained from professors belonging to the areas of Biology, Geology, Mathematics, Geography, History, Physics, Chemistry and Physical Education from grades 1-4. Most of them use resources such as videos, images, presentations and educational websites, but none of them use social networks in their teaching. The majority of teachers handle collaborative and cooperative learning, promote diversity and attention to diversity, although it should be noted that the use of ICTs does not imply a significant change in student learning, since it does not contribute to speed and easy access of content if this does not bring about changes in the traditional methodology. Finally, it remains to be said that, although it is true that ancient teachers use it more frequently, this is not due to their age, but because they have had more time to accumulate more teaching experience (Maldonado et al., 2019).

For its part, the study by Sanusi, Oyelere, Suhonen, Olaleye, & Otunla (2017) aimed to examine the activities, experiences, and impact that students and teachers have by implementing the Opón Ímó methodology for educational work in Osun. The rationale for this project is based on the use of mobile devices, which have a greater impact compared to a computer due to its mobility, accessibility, and ease of use. To begin the investigation, Sanusi et al., (2017) start from a project that the Osun government launched as an initiative to distribute twenty-five thousand four hundred and seventy-seven (25.477) tablets to students throughout the state. This device comes with an incorporation of various software for learning: audios, videos, texts, documents, state test drills from West Africa, which aims to bring the student closer to technology, make these tablets become another educational tool and enhance educational levels.

International studies reflect upon the need to continue investigating the teaching-learning processes and their incorporation with ICTs in secondary education institutions. They state that the use and appropriate training means that teachers continue to include active methodologies in the pedagogical practices, which empower students, but also bring them closer and closer to knowledge. In addition to this, a collaborative work

and interdisciplinary teaching is reflected. Continuing with this research line, the general objective of this study is to know the impact that ICTs have on the teaching practice of secondary education in the Colleges of Bogotá and Cundinamarca.

Methodology

The ethnographic study was selected for this case, since this qualitative method allows to interpret certain human communities and their customs, characteristics, traditions and their own identities (Maturana Moreno & Garzón Daza, 2015).

The characteristics of the selected institutions are presented in the following table:

Table 4.1
Characteristics of the selected institutions

Name of the institution	Location	Socio-economic Status (NSE)	ICFES Category	Sector	Calendar
I	Bogotá	3	A	government	A
II	Guataquí	2	C	government	A
III	Chía	4	A+	non-government	B
IV	Cota	4	A+	non-government	B
V	Bogotá	3	A	non-government	A
VI	Bogotá	2	B	government	A
VII	Bogotá	2	B	governmentl	A

Note: The sample, chosen among the total population of schools in Bogotá and Cundinamarca, was limited to seven schools conveniently chosen, considering the criteria of location, socio-economic level, ICFES category, sector, calendar, so that the analysis unit contemplates different perspectives.

Information gathering management

The objective of the ethnographic study was to develop a simple and easy-to-apply tool that allowed to know the pedagogical practices and teaching styles of teachers, the integration of didactics to ICTs, and the behavior and reactions of grades 10 and 11 students to the didactics that integrate ICTs.

The measurement tool used was designed under three categories which in turn are divided into three questions for each of them, for a total of nine items to evaluate. Each guide was used in each of the interviews, which is implemented to two teachers on average: one that has taught more than ten years and another that has been working in the institution for less than ten years. Likewise, there was a discussion group for each institution with students from grades 10 and 11 who would take classes with the selected teachers.

The three categories and subcategories that were evaluated are detailed in the tables 4.2, 4.3 and 4.4.

Table 4.2.
Category I. **Pedagogical practices and teaching styles of teachers**

SubCategory	Variable
I.1.	Use of digital tools
I.2.	Experience with the integration of methodologies and ICTs
I.3	Experience of student interaction with ICTs

Table 4.3
Category II. **Integration of ICTs teaching**

Subcategoría	Variable
II.1.	The implementation of ICTs has generated changes in student learning.
II.2.	With the integration of ICTs in the classroom, the student establishes relationships between topics.
II.3	The integration of digital activities has favored the cooperative work of the students.

Table 4.4.
Category III. **Student behavior and reactions to the didactics that integrate ICTs**

Subcategoría	Variable
III.1.	Aumenta la motivación de los estudiantes cuando se implementan actividades que integran a las TIC.
III.2.	El desarrollo de actividades digitales ha permitido impactar en el aprendizaje de los estudiantes.
III.3	Su formación y apropiación de las TIC incide favorablemente en el desarrollo de la sesión y en el aprendizaje de los estudiantes.

Analysis and results

For the analysis of the information, each of the categories was considered, as presented in Tables 4.5, 4.6 and 4.7 with their respective results. The name of the institutions is omitted, but they are granted the denomination of I, II, III, IV, V, VI and VII, which to the characteristics of the selected institutions.

Table 4.5
Category I: **Pedagogical practices and teaching styles of teachers**

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
I	Old teacher	Hardware: Laptops, desktop computer and tablets. Software: virtual environments and Moodle platform	Technology as a content generator: the students created their own videogame through the world programming page, the game is used as educational material	An open relationship and high expectations, in terms of technological tools and their operation.
	New teacher	The EVAP strategy which starts with meaningful learning and problem-based learning for the development of classroom learning.	Technological tools and support for curricular and extracurricular activities: Virtual platforms that allow 24/7 student connectivity.	The interaction of students seeks an objective of technological use, which comes from the interest in its operation. It is based on the curiosity of how technology works, and thus interest in it is created.

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
	Students	Teachers handle tablets, computers and laptops. In some cases, other elements such as interactive televisions are used. On a scale of 1 to 10, 7 is the frequent use of technology.	The use of technology is usually varied, since it depends a lot on its application and context when using it. In class, it is usually something different, since it is not so much the application of the hardware, but the softwares.	They tend to be more collaborative among the group because they are allowed to enhance communication within the educational context. The work is divided, and thus allows an individual contribution without complications.
II	Old teacher	Frequent use of the computer room, due to its unique provision of computers, tablets, laptops and a digital television. Depending on the activity, it adapts to the situation and the application of the devices.	Student motivation and participation is evidenced, so much so that at the end of the educational cycle students tend to create their own microenterprise or help 11 students for ICFES tests.	It shows greater emotion and acceptance by the mathematics and computer subjects in which the technology has to be incorporated more.
	New tacher	Uses the computer and speaker frequently for the development of activities in the area of English. Concerning digital material, they work with videos as much as possible due to lack of resources.	Relationship experiences: a project was developed with other areas that allowed to effectively relate the issues and their application through what was seen in class with ICTs.	There were complications at the beginning due to not having the habit of working with ICTs. However, communication and the incorporation of these have been strengthened in order to develop the skills that are sought within the subject.

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
II	Students	The computer is mainly used. For other activities, a television is used.	They are tools that allow to improve the understanding of the information.	It promotes collaborative work and requires the teacher to participate as a learning guide.
III	Old teacher	Hardware: mobile phone, TV and computer. Software: Videos, interactive classrooms and phone applications such as Demosgraf and GeoGebra	It is positive because there is no difference between integrating or not ICTs: The teacher seeks to provide spaces to integrate apps to the student learning process and thereby generate security and freedom when using them.	It allows you to easily capture attention. Being more graphic allows you to enhance your ability to understand. On the other hand, more initiative is generated to investigate and propose topics of study.
	New teacher	Digital material: Free virtual labs like Learn Genetics, Kahoot and videos.	Understanding and deepening of the topics: Through virtual laboratories it is possible to work on practical skills, it allows to improve the understanding of the theory and application of it. It encourages participation.	The implementation of ICTs makes the class more interesting, although there is always the possibility of distraction.
	Students	The cell phone is used in almost all subjects. Personal or desktop computers, televisions and video beams are also used.	It facilitates the information; it attracts the attention of the student to make the lessons more dynamic and finally allows to save time when carrying out the activities.	It tends to be distant when using ICTs, each student is doing their own thing. However, this is due to the activity, such as digital quizzes or group work, which requires more communication between students.

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
IV	Old teacher	The indispensable tool is the Internet. This is because most of the work is done on school platforms, painting programs, presentations in Prezi or Camba.	The technological age to which the student belongs requires that the teacher innovate or implement the technology. However, it does not mean that the traditional activity such as reading, underlining, among others is abandoned, but that it encourages new spaces and methods of application.	There is a free space in the way of working. Even though areas such as social sciences require other skills, the teacher takes care to bring the student closer to the implemented ICTs area, being interested in their experience and their relationship inside and outside the classroom.
	New teacher	Computers and television, in digital material such as blogs, presentations in Camba, among other programs are used.	It is about implementing a context, case or activity where the student can analyze and apply the method.	It allows to approach and relate, through the playfulness in which technology mediates, the issues with real cases making it more striking for them.
	Students	A variety of platforms such as MyMatsLabs and MyEIL are used. Laptops, and technology and computer rooms are used as softwares.	They are oriented mainly to the benefits that have had the use of technology, since it allows them to deepen the issues, facilitate access to knowledge and even encourage research.	Through collaborative work, on the one hand, it allows the student to have some autonomy and responsibility to work, and on the other hand, it allows to create an orientation relationship between the teacher and the student.
V	Old teacher	They frequently use tablets and applications for students to develop different skills.	Students are currently seeking closer experiences, so implementing ICT in their learning process is important for them, since it allows them to approach information, to different contexts, where they can observe their applications with real life.	It usually improves the skills raised in the activities. On the other hand, it favors the approach with the content to teach which is accepted by them.

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
V	New teacher	The mobile phone is implemented inside the classroom. The digital material allows the freedom to use what they think is necessary. However, the only filter is the reliability of the information, a habit taught by the teacher.	It starts from the dynamism of work; they tend to be more active during class activities when the use of technological devices is incorporated.	The dialogue and its investigative work show the way of working, since the teacher focuses on solving the problems and concerns that arise during the research activities.
	Students	Generally, television and cell phones are used. Within the digital material videos, files and digital books are used for the activities.	It gives dynamism to the lessons and allows to access a large amount of information in a short time.	There is no major change, working with or without technological tools is usually the same, although it is always about promoting the use of ICTs.
VI	Old teacher	Classroom of applied technologies: computers. Design software, CNC, Power Point, Word and Excel	It gives them a workspace that encourages the development of design skills.	The interaction: there is greater interest and they are more motivated by the activities and content thet implements ICTs.
	New teacher	Mainly the use of computers and pages, programs and other softwares: Office, Publisher and Accounting softwares.	It allows to advance and demand various educational processes, which are significant for the learning process in each student.	They are uneducated users in technology; therefore, they should be trained in digital culture to encourage use within their development.
	Students	Software room: Computers, laptops and tablets.	It has been helpful in carrying out class activities, since it requires prior management of the equipment that ends up encouraging them.	It depends on the way of work, it is usually minimal when you want everyone to work or can be supportive for them, when it is collaborative work.

Institution	Interviewed	Sub Category I		
		1.1	1.2	1.3
VII	Old teacher	The only means is the Computer, such as software and support material, online exercises, Office tools and Google.	It is novel, allows to develop group activities, quizzes and workshops that favor and incorporate evaluation practices.	The platform they handle allows to follow up on the student and help them solve their questions.
	New teacher	Accounting programs, the entire Office package, Prezi and videobeam projections.	Awakens interest in the interaction between them and participation in class.	Work by projects, the material is provided to then go to practice through a technical level work.
	Students	TV, cell phone, devices and videos.	They are tools that improve the understanding of the topics.	They improve the class while keeping the student's attention active during class.

Note: Pedagogical practices and teaching styles of teachers, when evaluating digital devices and tools, the teacher tends to make frequent use of mobile devices or computers. Other options include laptops, televisions, tablets and multimedia playback media. The teaching material tends to be made up of institutional platforms, free virtual laboratories, presentation, and design pages like Camba, Prezi and blogs and work softwares as well as programming softwares, Drive, and applications such as Kahoot, GeoGebra, among others. Own design, Source of information: Interview transcript matrix

Regarding the experiences with the integration of ICTs, it is highlighted that the use of these digital tools and materials favors the dynamism of the work method, which also allows to deepen the knowledge of the subjects and approximates the student to theory and practice, which enables learning. Spaces are also favored for the development of skills and competencies, such as interdisciplinarity. On the other hand, it requires the teacher to be very aware of the activities, which leads to the importance of being trained in the use of technological tools and devices.

In this way, a panorama is visualized where the teacher becomes a guide that applies the use of technology, allowing the behavior to be related to Skinner's theory of operant conditioning which causes students, in this

case, to change their way of behaving due to the new context and rules that are being applied (Šimandl & Vaníček, 2017).

When evaluating the interaction between students, it can be evidenced in the first measure that, in most cases, ICTs favor collaborative work, even if the technology is not fully implemented. The teacher cannot forget their role as a resource facilitator who must guide the learning processes. Secondly, the existence of multiple work modes is highlighted. Some teachers make use of teaching resources such as workgroups, where they promote the use of technology to enhance communication with students inside or outside the classroom. This is achieved through individual or group activities such as tasks, workshops, and research where they themselves use digital tools.

However, in a few cases, the use of technology is not essential, since there are situations where resources are limited, preventing its continued application. And thirdly, topics such as the absence of ICT culture are reviewed, in the sense that the institution does not have the educational vision of those tools that favor, enhance and energize the educational process and that the teacher must implement to provide closeness to teaching-learning processes.

Table 4.6
Category II: Integration of didactics into ICTs

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
I	Old teacher	The change is not evident in the subject, but in others, since the student goes to the teacher to change the methodology.	There is a relationship between the issues as to how to process the information or its application method, since the activities allow one or more procedures to be applied, which have been previously seen.	It can be evidenced through attendance, since if students wish to learn about technological issues they must attend at irregular hours, therefore, dedicate their own time to assist.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
I	New teacher	The activities imposed on them is a challenge since it gives them a new meaning in the learning process.	Indirectly, in relation to the topics, since when carrying out an activity the student has some freedom to implement, within their development methodology, the skills learned in other subjects.	Through the challenge, motivation is given to work individually or in groups, since they develop leadership competencies, teamwork, roles that allow them to stand out within the activity suggested by the teacher.
	Students	It is related to its breadth and increase of knowledge in the topics to learn; although this also goes hand in hand with the teacher's guidance since the student recognizes that without it, it be harder for them to learn its proper use.	There are two cases. The first is where the tools are given since their replication is sought in other processes of other subjects. The second is the teaching of the class since it also depends on the support material or the teacher's guide to carry out a relationship between the themes of the same area or another.	It favors collaborative work since there are many media such as social networks, pages, and applications that allow to narrow the distance between them. However, this depends on the habits of use and responsibility, since there are cases where it affects teamwork.
II	Old teacher	It has been positive; however, this change is not only based on implementing ICTs, but goes hand in hand with teacher guidance.	It generates spaces where you can make connections between a subject with other subjects, in this case it is not given at the initiative of the teacher.	Not only do they enhance communication, but they are a means for teacher feedback and assistance when there are problems with teaching.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
II	New teacher	Generate changes in student learning and allows spaces to improve skills and abilities.	Each subject is responsible for interdisciplinarity since the content is so flexible that it allows using topics in the areas of social sciences, religion, mathematics, chemistry, and biology with subjects such as English.	They favor cooperative work when it comes to helping the other. However, it can start as an initiative of the teacher or the same student.
	Students	It can be seen when the learned knowledge is used in the school in work areas such as social practices, extracurricular work, among others.	It depends a lot on the area, since computer issues can be related to subjects such as trigonometry, physics and chemistry.	Thanks to the development of digital skills, the agility in the management of technology allows collaborative work, since they worry about instructing each other when there are difficulties for some of them.
III	Old teacher	There is change, however, it is not in its entirety, since there are still students who do not get much attention. This impact has come through the deepening and progress of the issues; some of them tend to be complex for the student, but thanks to ICTs, it is possible to teach more easily.	The relationship between various subjects comes from the teacher, it is he who is responsible for demonstrating its practicality and connection with other fields or contexts.	The method of work is research, thanks to it, students socialize and communicate with each other to develop activities in class or at home. The freedom to choose the way to contribute to the delivery is also achieved.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
III	New teacher	It is believed that implementing ICTs makes the learning process more familiar and practical for the student.	Indirectly the relationship occurs, since applying the digital material allows to relate the themes or theory with the practical.	Provide an extracurricular space for the elaboration of works. These tools facilitate team collaboration through tools, such as Drive, to make a paper or a report.
	Students	It allows greater accessibility to information and communication, since immediately accessing information during educational activity is striking for the student.	Participate in case exercises, which are created by the teacher, where knowledge of various subjects must be applied to solve the problem. An integrated education was implemented in the institution, where various subjects from various areas were taught in a single class or exercise.	It favors teamwork because it prevents situations, such as lack of resources because it allows access to all the material and tools for the learning process.
IV	Old teacher	They offer many opportunities; however, this does not mean that certain traditional methods should be left aside. The teacher must seek a relationship between them to generate a balance in the use of each.	Your comfort favors your acceptance of knowledge. When they have a space to apply knowledge, the construction and relationship of topics generate a facility in aspects such as age limitations or concepts, becoming something striking.	They are adapted as tools to accompany, rather than mediate in communication because they allow making a consultation or simply communicate with the teacher.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
IV	New teacher	Try to guide with real situations through digital tools.	From the English area, spaces such as interdisciplinary academic projects are fostered where participation allows to relate the issues to other areas.	Different activities are carried out, but there are still cases where the student is distracted.
	Students	The experiences are positive, since spaces are created where feedback and deepening is essential. On the other hand, it provides a space to promote self-learning.	The school curriculum seeks to prioritize interdisciplinarity. These spaces and projects seek to replicate the knowledge of each subject through fieldwork. This process tends to integrate technology as a tool that facilitates the process to its participants.	They use digital tools like Google Docs to promote collaborative work.
V	Old teacher	Promotes the development of manual and mental skills.	It seeks, through the curriculum, to integrate other areas, skills and resources between subjects to create a comprehensive environment.	It requires developing teamwork skills and when they do distance activities the teacher takes the role of observer to guide the academic process.
	New teacher	Facilitates the approach to tools, which were previously additional, for example the calculator, which has been replaced by the phone or an app.	Through the implementation of projects, skills, abilities, and other things that favor learning are oriented and integrated.	It is essential, through role play, since various work modes are integrated in favor of the project to work.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
V	Students	It has allowed the development of skills and competencies necessary to overcome challenges imposed by the teacher. This goes hand in hand with the application of processes and content advancement.	Many skills and competencies are integrated to carry out projects that end up becoming transversal for their training.	In the absence of work resources, solutions are proposed that generate significant learning and then, through the implementation of ICTs, allows replicating in other contexts.
VI	Old teacher	Forces them to be more autonomous and develop skills for their training and technology management	Developed skills become tools for others.	When they must carry out activities to create or design, some tend to focus on their work and others tend to support others while working on their part.
	New teacher	It has allowed attracting support for the institution by improving the projection of its graduates.	It allows them to have bases and work tools to implement them in other areas.	Teamwork favors responsibility in teamwork, which integrates the contribution of each of the members.
	Students	It has allowed to create spaces to improve academic processes, contextualize and identify various cases to apply what has been learned.	The subjects allow to apply, through contextualization, different knowledge and skills.	It encourages the organization to work from home in group exercises.

Institution	Interviewed	Sub Categories		
		2.1	2.2	2.3
VII	Old teacher	The change is not evident in the subject, but in others, since the same student goes to the teacher to change the methodology.	There is a relationship between the issues as to how to process the information or its method of applying it, since the activities allow one or more procedures to be applied, which have been previously seen.	It can be evidenced through attendance, since if students wish to learn about technological issues they must attend at irregular hours, therefore, dedicate their own time to assist.
	New teacher	In defiance of the activities imposed on them, since it gives them a new meaning in the learning process.	Indirectly, in relation to the topics, when carrying out an activity, the student has some freedom to implement, within their development methodology, the skills learned in other subjects.	Through the challenge, motivation is given to work individually or in groups, since they develop leadership competencies, teamwork, roles that allow them to stand out within the activity suggested by the teacher.
	Students	Regarding its breadth and deepening in the topics to learn, this also goes hand in hand with the teacher's guidance because the student recognizes that without it, it would cost him to learn its proper use.	There are two cases. The first one is where the tools are given since their replication is sought in other processes of other subjects. The second one is the teaching of the class since it also depends on the support material or the teacher's guide to carry out a relationship between the themes of the same area or another.	It favors collaborative work, since there are many media such as social networks, pages and applications that allow you to cut the distance between them. However, this depends on the habits of use and responsibility, since there are cases where it affects teamwork.

Note: Regarding this second Category and Subcategories, where the didactic Integration of ICTs is analyzed, the first item makes it possible to demonstrate that there is a significant impact for students due to the greater implementation of

technological devices or digital materials. Although the answers tend to analyze the change in the student, the teacher feels part of the change. It can be noticed, especially, in the old teachers. A second aspect to consider is the emphasis given on the proper use of technology, since the technological habit of using this series of tools within the classroom without a teacher's guide does not yet exist. As a third and last aspect, the integration of ICTs not only allows generating spaces for feedback, self-learning, and interest about the operation or processes but also seeks to take certain traditional activities hand in hand with technology to generate a balance between old and new skills. Own design, Source of information: Interview transcript matrix

Similarly, when seeking to guide learning, interdisciplinarity is worked on. For this, tactics such as transversal and personal projects, case studies, activities, guides, even process relations are used. These are the methods most used by these teachers to allow the implementation of the theoretical aspect through digital media or technological tools. In addition, this expresses an interest in the same educational institutions to promote interdisciplinarity. There are cases where students, on their own, due to concerns, examples of real-life or personal tastes, tend to show interest in deepening the issues through the inclusion of ICTs.

The third subcategory of this second aspect was aimed at observing the integration of ICTs as a means of communication and work among students. One of the aspects to emphasize was the access that students have to be able to work as a team since the majority of technological tools allow to enhance teamwork inside and outside the classroom. The interaction with the teacher is mentioned, which has allowed them to take on the role of facilitator, guide, counselor and even generator of contexts, which the student accepts with comfort, to evaluate, monitor and control the continuous process of their students.

In this category, there is a lack of appropriation, modification, and replication of resources. In educational institutions, it is a question of looking for this process by which this type of research is carried out since it has become part of the educational method to innovate and generate added value to existing resources (Sánchez & Toledo, 2015).

Table 4.7.
Category III: Student behavior and reactions to the didactics that integrate ICT

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
I	Old teacher	Incident value in the motivation. On the other hand, it is commented that the dynamism of the class, the methodologies, and digital tools allow continuing with that motivation in comparison with a master class.	The activities and methodologies have allowed impact through their professional projection, they have an interest in careers that have a relationship with technology and digital content management.	It has generated greater ease to approach their students, this allows a greater understanding on the part of the students regarding the complexity of the subjects.
	New teacher	The methodology, tools and activities enhance motivation. In this case the teacher allows the student to participate in spaces where they can develop these technological skills.	The impact of ICTs reaches a magnitude in which it not only manages to change the way of learning but also allows teachers to be reached as they become guides for their students.	Technology mediates relationships. Didactics goes hand in hand with ICTs as it facilitates the understanding of information.
	Students	When working with teachers who have to include ICTs in their classes, it feels more comfortable in the classroom for the student. However, the importance of the teacher in the classroom is recognized.	There is a change in the environment. Many processes are facilitated, one of them is self-learning as interest in research and learning is encouraged, although it is agreed that teacher guidance and tutoring needed.	From the experience in integrated media lessons: technology is usually more a tool than a necessity, it favors clarity in the issues to be seen, although it is usually implemented for practice. There are situations where an activity involves, by custom, using a digital medium or a technological device.

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
II	Old teacher	It has been positive, since it is possible to show greater participation, questioning and interest in investigating.	The activities with the greatest impact are those that require a greater understanding of the subject as ICTs have improved the transmission of the theory and therefo-re its replication in activities, works-hops or exams.	It allows the teacher to take the class more calmly, without so many distractions, in generating motivation for their students.
	New teacher	It allows to capture the attention of the student; it is striking for them to make use of technological devices because their proximity to the information allows them to better capture the theory.	In the area of English, it has been shown in both the development of competencies and habits versus using technology.	Approaching various resources that, through ICTs and instructions, have allowed impact within learning to improve their skills in a short time.
	Students	It has been given in the responsibility and in the capacity to carry out the activities with greater efficiency and agility.	Allows to increase knowledge in topics that in class tend to be complex, since ICTs provide a space to review the various thematic processes.	Encourages during classroom activities and create spaces to feedback and deepen topics.
III	Old teacher	It is usually stopped by the procedure, the student is bored with the same step by step, so they tend to look for other methodologies and tools.	Through deepening and research, ideas are brought to understand the application of the topics and encourage research practice with technology.	The teacher has made a transition of 20 in teaching, which allowed us to observe the change in the needs of students to rethink and innovate their way of teaching.

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
III	Old teacher	It is usually stopped by the procedure, the student is bored with the same step by step, so they tend to look for other methodologies and tools.	Through deepening and research, ideas are brought to understand the application of the topics and encourage research practice with technology.	The teacher has made a transition of 20 in teaching, which allowed us to observe the change in the needs of students to rethink and innovate their way of teaching.
	New teacher	The student tends to propose the work method, although the teacher must also go hand in hand with traditional practices because not all students feel at ease using ICTs.	Favored in the improvement of experiences, which for reasons of displacement, money, necessary resources, among others can affect the full performance of these activities.	It facilitates the explanation of examples. They also allow creating a communication network where it is possible to share the experiences of teachers in different parts of the world, which is enriching for the teacher to solve didactic problems.
	Students	Lessons where ICTs are incorporated are usually more dynamic, creating a comfortable environment that allows students to eliminate student complexities.	The visual content has optimized the understanding, since there is material to review the basic and the most complex topics.	Just as ICTs have advantages, there are also disadvantages such as the distraction by certain digital uses.
IV	Old teacher	The dedication and work method allow to demonstrate the motivation that the student has taken when linking the virtual environment with questions of knowledge construction since for them it is more striking to work in this way.	There are a lot of tools to improve the quality of learning, however, the teacher's orientation is usually left aside when their job is to be a participant in helping to develop the necessary skills for its correct use.	The usefulness of the tools varies their application, they can facilitate the preparation of a class, the projection of examples to understand the context and the activity in the learning processes.

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
IV	New teacher	It has allowed to integrate the opinion of the student, that they themselves are participants in the academic space to perform different activities.	Through the ICT and the various interdisciplinary projects, the student has been improving their learning and practice methods.	It facilitates the work in the sense that through the multiple activities the compression of the topics is achieved.
	Students	It can be relative in the sense that it is used. According to its application and handling, it tries to be motivating as it can also be distracting.	Create feedback spaces that, at the time of being evaluated, favor the process and application of your knowledge.	It depends on the disposition since if it is applied it can be oriented to a process that does not have great meaning, the impact is not reached to search, as in cases where it does manage to be significant.
V	Old teacher	The various softwares favor interaction with the student to improve learning.	It allows to generate spaces to project the professional context, since ICTs allows the student to be approached with various work tools. They can be technical or technological.	ICTs have allowed to implement examples, schemes, among others that favor the integration to the academic process.
	New teacher	It allows to easily develop the understanding of the educational content since it interconnects the themes of the subjects with their student work.	It generates changes in the limits and expectations of the teacher. The results allow us to show the impact it has had.	They have favored the educational processes since they propose challenges to overcome each time the desired goal is reached. It also requires the teacher to be in full update of content and tools.

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
V	Students	Through work support, the deepening of knowledge and interest in helping and surpassing others is favored.	It facilitates the learning, process, and development of skills necessary in education and in your tastes, as it encourages research.	It depends: the management of ICTs can disorient or guide the activity raised by the teacher.
VI	Old teacher	Although saturation is not good, working in an environment where there is diversity and continuous activity is sought.	They have been significant due to the methodology that seeks a balance between innovative and traditional practices.	It is a challenge and helps, a challenge in terms of handling technological novelty and helps as it is a tool that becomes fun for the student. Everyone learns, it is a tool that makes work methods.
	New teacher	It facilitates the expression and understanding of your personality.	Through the aid, the student's attention is attracted to be willing and comfortable in class, projects, work teams and among other contexts.	They are tools that allow the change of the didactics within the curriculum generating a significant impact for the student and the teacher.
	Students	It favors the teaching method, since there are things in which the teacher cannot express himself clearly.	Using ICTs, various exercises are carried out that favor the understanding and deepening of the topics.	ICTs favor the knowledge landscape, since strengthening these spaces allows improving the quality of education.

Institution	Interviewed	Sub Categories		
		3.1	3. 2	3.3.
VII	Old teacher	Attendance is an incident value in motivation. On the other hand, it is commented that the dynamism of the class, the methodologies, and digital tools allow continuing with that motivation in comparison with a master class.	The activities and methodologies have allowed impact through their professional projection, they have an interest in careers that have a relationship with technology and digital content management.	It has generated greater ease to approach students. This allows a greater understanding on the part of the students regarding the complexity of the subjects.
	New teacher	Methodology, tools, and activities enhance motivation. In this case, the teacher allows the student to participate in spaces where they can develop these technological skills.	The impact of ICTs reaches a magnitude in which it not only manages to change the way of learning but also allows the teacher to be reached as they become a guide for their students.	Technology mediates relationships. Didactics goes hand in hand with ICTs as it facilitates the understanding of information.
	Students	When working with teachers who have to include ICTs in their classes, they feel more comfortable in the classroom for the student. However, it comes to recognize the importance of the teacher in the classroom.	There is a change of environment; a facility of many processes is generated, one of them is self-learning since interest in research and learning is encouraged, although it is agreed that teacher guidance and tutoring is needed.	From the experience in integrated media classes: technology is usually more a tool than a necessity, it favors clarity in the issues to be seen, although it is usually implemented for practice. There are situations where an activity involves, by custom, using a digital medium or a technological device.

Note: Own design, Source of information: Interview transcript matrix

Regarding the third category, whose objective was to evaluate the behavior of students and reactions to the didactics that integrate ICTs, it can be observed that in terms of motivation, it has, on the one hand, great significance for students when they work with technology. In most cases, it allows the creation of educational spaces where freedom to participate is provided to develop activities with comfort, ease, efficiency and without fear of erring in the process, since the orientation of the teacher during their academic activity is constant. On the other hand, motivation is usually a fundamental point in the work of the teachers. Through it, they can capture attention, participation, improve attendance, encourage the student through traditional processes such as content comprehension, critical reading, writing, research, among others, that are sometimes left aside when working with ICTs, which is usually a mistake because even students recognize the importance of developing these skills.

However, the impact that the inclusion of ICTs in the classroom shows that there is a greater implementation of ICTs as a tool for solving problems. They are applied with frequencies to improve research processes, feedback, deepening of issues and processes in practice. From the point of view of the teacher, these tools have been responsible for motivating the student to project themselves professionally, however, many of them usually continue with a career that integrates ICTs or digital content.

Finally, it is usually more feasible and practical for educational institutions and for teachers to make use of technology to provide didactic spaces by not requiring travel, generating a cost and taking more time than the class, or even not of interest to participate in it, as it facilitates contact, through virtuality, between the practical field, knowledge and the student.

In order to observe what the contribution is, or the improvements, that the students bring to the educational process, the results show that ICTs allow teachers to improve their academic work, favors the realization of activities and strengthens their planning. The student's vision shows that there are cases where inclusion creates an environment that favors the motivation and execution of activities, provides them with the tools and material needed to work inside or outside the classroom. However, shortcomings are recognized in digital education, or the habit of using ICTs,

since, as well as there is a wide variety of resources for education, there are usually many distractors who, without teacher guidance, impair the educational process in class.

Finally, it should be noted that digital tools and technological devices are great means to get attention and establish better communication. However, this does not mean that only through them can these objectives be achieved, since there are tools and digital material that requires proper use.

Discussion

According to the objectives and the fieldwork developed, it is possible to demonstrate that, when answering the research question related to the impacts of ICTs in the practice of secondary school teachers in the schools of Bogotá and Cundinamarca, it is evident that both in studies and in fieldwork there is a marked impact on doctoral practices and these are related to training and use in the integration of ICTs.

Regarding the specific objectives, it was established that when designing and applying instruments related to teaching-learning processes, it is possible to demonstrate the integration of ICTs in the classrooms and, specifically in grades 10 and 11, the motivation factor as well as the impact on student learning.

When reflecting on the process of improving the quality of education in terms of the integration of ICTs in secondary and basic education, it is emphasized that it is necessary to permanently train teachers, as described by Morales, Ramírez , Vargas & Molina (2018). The authors state that factors that influence the teaching process, also perceived by the students, are teachers' motivation, dedication, methodological strategies and their knowledge, as well as the good use of resources in teaching-learning processes.

Regarding the pedagogical practices and teaching styles of teachers, as well as the integration of didactics to ICTs and the behavior of students in grades 10 and 11, it is ratified that:

1. Pedagogical practices including ICTs have a high impact. Students and teachers consider it favorable in the teaching-learning process.

2. By integrating ICTs into the didactics, most teachers interviewed appreciate the impact that is evidenced in the students' learning, but at the same time consider that they should be trained to properly use them.
3. Regarding the behavior of students of grades 10 and 11, both teachers and students show the degree of motivation that exists when ICTs can be used while working in an active and cooperative way.

References

Acosta Corporan, R., &y Hernández Martín, A. (2014). Collaborative learning methodologies mediated by ICT in secondary education. *Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality - TEEM '14*, 689–693. doi: 10.1145/2669711.2669975

Başak, M. H., &y Ayvaci, H. Ş. (2017). A comparison is aimed at the integration of the technology in education system; As an example of "Turkey and South Korea." *Egitim ve Bilim*. doi: 10.15390/EB.2017.6710

Briceño Martínez, J. J., &y Castellanos Saavedra, M. P. (2016). Diplomados para la formación de docentes en el uso pedagógico de las TIC. *Opción*, *32*(11), 164–178. Retrieved from http://produccioncientificaluz.org/index.php/opcion/article/view/21940

Castellar Paternina, E. (2011). Diagnosis of the use of ICT in three state schools of Soledad (Atlántico). *Revista Del Instituto de Estudios En Educación Universidad Del Norte*.

Córdoba Castrillón, M. (2017). Estudiantes de la básica y media con respecto al uso de las TIC como herramientas de apoyo a su aprendizaje. *Trilogía Ciencia Tecnología Sociedad*, *9*(16), 113–125.

Cortés Muñoz, S., Vargas Ordóñez, T., &y Neira Díaz, J. (2017). Uso de las TIC en la práctica pedagógica. *Tecnología Investigación y Academia*, *5*(1), 46–56.

Cuadros, J. A., Valencia, J., &y Valencia, A. (2012). Las tecnologías de la información y la comunicación en entornos de aprendizaje rural como mecanismos de inclusión social. *Actualidades Pedagógicas*, (60), 101–120. doi: 10.19052/ap.1756

Domínguez Alfonso, R., Hernández Mendo, A., &y Chica Merino, E. (2018). Development and validation of a questionnaire for evaluating the impact of ICT in secondary schools. *Digital Education Review*, *0*(34), 1–26. doi: 10.1344/der.2018.34.1-26

Fernández Cruz, F. J., Fernández Díaz, M. J., &y Rodríguez Mantilla, J. M. (2018). El proceso de integración y uso pedagógico de las TIC en los centros educativos madrileños. *Educación XX1*, *21*(2). doi: 10.5944/educxx1.17907

González, J. R. B., Cardona, M. O. B., &y Montoya, F. L. V. (2017). Creación de una comunidad de práctica para la formación de docentes en la integración de las TIC a los procesos de aprendizaje y enseñanza de lenguas extranjeras. *Ikala*, *23*(1), 121–139. doi: 10.17533/udea.ikala.v23n01a09

Hernandez, R. M. (2017). Impacto de las TIC en la educación: Retos y Perspectivas. *Propósitos y Representaciones*, *5*(1), 325–347. doi: 10.20511/pyr2017.v5n1.149

Hernández Rivero, V. M., &y Sosa Alonso, J. J. (2016). Profesorado revista de curriculum y formación del profesorado. *Profesorado*, *20*(3), 433–466. Recuperado de: https://recyt.fecyt.es/index.php/profesorado/article/view/54618

Liestol, G., Doksrod, A., Ledas, S., &y Rasmussen, T. (2012). International journal of interactive mobile technologies. *IJIM*, *6*, 18–24.

Maldonado-Manso, P., Ruiz-Palmero, J., Gómez-García, M., &y Soto-Varela, R. (2019). Analysis of the Use of ICT in Compulsory Bilingual Secondary Education in Andalusia Public Schools. Case Study. In *9th International Symposium on Ambient Intelligence* (pp. 373–380). doi: 10.1007/978-3-030-01746-0_44

Maturana Moreno, G. A., &y Garzón Daza, C. (2015). La etnografía en el ámbito educativo: una alternativa metodológica de investigación al servicio docente. *Revista Educación y Desarrollo Social*, *9*(2), 192–205. doi: 10.18359/reds.954

Melo Fiallos, D. F., Silva Chávez, J. A., Indacochea Mendoza, L. R., &y Núñez Campaña, J. H. (2017). Tecnologías en la educación superior: políticas públicas y apropiación social en su implementación. *Revista Digital de Investigación En Docencia Universitaria*, *11*(1), 193–206. doi: 10.19083/ridu.11.498

Morales Piñero, J. C.; Ramírez Acosta, N. E.; Vargas, S. H &y Molina Bernal, I. A. (2018). Dificultades en el proceso enseñanza-aprendizaje dentro del aula de clase e influencia de las TIC para minimizarlas. In *Las TIC, la innovación en el aula y sus impactos en la educación superior* (Vol. 1, pp. 57–82). Bogotá: Publicaciones Universidad Sergio Arboleda.

Peláez, L. E. &y O. B. E. (2015). Medición del nivel de aprendizaje con dos escenarios de formación: uno tradicional y otro con TIC. *Entre Ciencia e Ingenriería - Universidad Católica de Pereira*, (18), 59–66.

Sánchez García, J. M., &y Toledo Morales, P. (2015). Aproximación al uso de recursos educativos abiertos para ciencias sociales en educación secundaria y bachillerato. *Prisma Social*, (15), 222–253. Retrieved from https://www.redalyc.org/articulo.oa?id=353744533007

Sanusi, I. T., Oyelere, S. S., Suhonen, J., Olaleye, S. A., &y Otunla, A. O. (2017). Exploring students and teachers activities, experiences and impact of Opón Ìmò mobile learning device on teaching and learning. *2017 IEEE AFRICON*, 788–793. doi: 10.1109/AFRCON.2017.8095583

Šimandl, V., &y Vaníček, J. (2017). Influences on ICT teachers knowledge and routines in a technical e-safety context. *Telematics and Informatics*, *34*(8), 1488–1502. doi: 10.1016/j.tele.2017.06.012

Chapter 5

Educational software and its impact on the learning process in university

Henry Martínez León [1]; Gloria Tarrío Villaverde [2]

Abstract

This chapter describes a study carried out in 2019 which evaluated the use of ICTs, specifically the LógicaUCAB educational software, and its effects on students' learning of the Propositional Logic content from the Computing Logic course of the Computer Engineering degree of the Universidad Católica Andrés Bello (UCAB). Two groups of students were selected: an experimental group, who used the LógicaUCAB tool in a laboratory during five weeks, one session per week, and a control group, which did not have access to the software. The official UCAB platform (Módulo7-Canvas) was also used for virtual activities. The research methodology was quasi-experimental, since groups were formed non-randomly. Finally, a written test was applied to both groups to verify results. These showed a positive effect on the academic performance of the students regarding the Propositional Logic content when using LógicaUCAB in the Computational Logic course. Based on this experience, a program that can be further applied and that con-

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tributes to student learning of Propositional Logic is formally detailed, through the use of an Educational Software and some other ICT tools.

Keywords
Educational software, logic, computational logic, propositional logic, ICTs, deduction, deductive logic, logic derivations

Problem statement and justification

Information and communication technologies (ICTs) have become a part of today's culture, and the educational field is not excluded from it. Educational institutions cannot fail to consider this technological competence when designing curricula or programs, especially competency-based curriculum, which focuses on students' integral learning. Skill-based teaching focuses on acquiring knowledge and learning abilities and attitudes useful in all contexts: individual, academic, professional and social. Teacher leadership must therefore be transformative, as ICTs must be incorporated in curriculum renewals.

Students entering college today, particularly in Venezuela, experience a rough change from high school to the university environment, probably due to various factors worthy of study, including the low quantity and quality of conceptual and procedural knowledge that the student should master by then but does not, and the lack of techniques and study habits which previous schooling should have provided. Furthermore, the political and economic situation of the country demotivates students and even incites both them and teachers to drop out (Albarrán Peña, 2019).

Aside from dropout rates, results from the first academic periods evidence that something is wrong. UCAB professors constantly discuss the situation in the Engineering Department and Faculty Councils, as the authors of this study, who are members of said councils, can endorse. According to various investigations (Dubon, Navarro, Pakhrou, Segura & Sepulcre, 2013; Pérez, Castellanos, Díaz, González-Pienda & Núñez, 2013; Silva, 2011), students' deficiencies are particularly reflected in the lack of study habits and of self-regulation strategies, that is, in the absence of efficient habits for the autonomous, active and critical acquisition of formal knowledge, and specially of problem solving abilities and numerical reasoning. Pérez et

al. (2013) stress that it is important to include the teaching of self-regulation strategies as part of the curricular program.

The Computational Logic course is part of the study program of the Computer Engineering Department in the UCAB and is taught in the second semester. Due to the low performance of new students, the Computer Engineering Department decided to change the curriculum in 2008, reinforcing mathematical contents that are included in national high school programs. Basic mathematics and trigonometry courses were included in the first semester in order to help students strengthen their knowledge and skills in this mathematical area. This change had a positive impact on results from subsequent semesters, especially in courses with mathematical content such as Calculus I. However, no change in performance for Computational Logic was perceived, due to the fact that new courses are instrumental and do not address directly the development of logical thinking.

Computational Logic demands mathematical logic, where formal reasoning is developed through the representation of well-supported arguments. Basic Mathematics is a requirement to start this course, since it provides a foundation for the development of the student's algorithmic thinking. The skill of deduction that is obtained with Computational Logic can be considered a form of programming. The development of this competence prepares students for further learning regarding programming, and it is precisely in the area of propositional logic where students get worse grades. Propositional logic is a branch of mathematical logic responsible for studying reasoning from simple elements called propositions, which can be true or false. Reasoning starts from several premises, which are propositions that are assumed to be true, and from which a valid conclusion can be inferred.

Dating a few years back, the Computer Engineering Department has shown interest in investigating the reasons for poor performance in the Computational Logic course. Various technological tools have been studied seeking to help students in their learning process, particularly in the Propositional Logic content course. This content is dictated in the first six weeks of the semester. The authors of this research have taught Computational Logic for more than 10 years and have conducted various tests with ICT tools, particularly in 2013 and in 2018.

This study aimed to review the effect of using educational software and some other ICT tools on the content of Propositional Logic. Research hypotheses were established, and the appropriate methodological design was selected to carry out the study according to the objectives. Finally, data analysis and interpretation are detailed in order to verify or reject the hypotheses proposed.

The following hypotheses were tested:

1. The application of the educational software LógicaUCAB has a positive impact on the academic performance in the Propositional Logic content of the Computational Logic course in the Computer Engineering degree in UCAB.

2. The results of the scores of the experimental group will be significantly better than the results of the control group in the written exam applied at the end of the research.

Based on these hypotheses, the following objectives are derived:

1. Determine the effect of the use of educational software on the academic performance of students in Propositional Logic, one of the contents of the Computational Logic course in the Computer Engineering degree;

2. Determine the differences between the results obtained in the experimental and the control group;

3. Design and implement a program that guides teachers and students in teaching and learning Propositional Logic content using ICT tools.

State of the art

Academic performance defines the state of education in a country and is generally associated with grades. Academic performance can be measured following various criteria, quantitative and/or qualitative. The quantitative measure of performance assesses students' learning process and is observed in their grades, graduate and dropout rate, and the degree of academic success (García & Tejedor, 2017).

According to Gomez, Oviedo & Martinez (2011), academic performance is directly related to teaching and to how students respond to it;

however, not all learning is the result of this action. Autonomous student learning and the use of ICTs play a prominent role in shaping current student achievement (Han & Shin, 2016). For Moreno & Ramírez (2011), some advantages of ICT use are the increase of motivation and protagonism in the educational process, as well as the encouragement of students' initiative, which contributes to the self-regulation of their learning and which positively affects their performance.

There are lines of research on the effect of ICT use on student achievement. García & Cantón (2019) evaluated the impact of five technological tools on the academic performance of four courses in a sample made up of 1.488 adolescents from nine educational centers. One of the authors' conclusions is that the use of an ICT tool can have positive but also negative effects in different areas. What matters most is that the teacher knows and properly applies the technology to achieve the desired impact (Gil, 2012; Torres et al., 2016; cited in García & Cantón, 2019).

García & Tejedor (2017) conducted a different study on the potential of ICT use in developing learning strategies and its relationship with academic performance from the students' perspective. The authors found that the students who valued ICT support more obtained better grades.

Not all researches find significant evidence to affirm that there is a positive impact on performance associated with ICT use. Botello & López's (2014) study shows that ICT use can improve reading and academic performance of fourth graders, yet this improvement does not only rely on ICTs, but also on the effectiveness of each teacher's strategies.

Martínez & Heredia (2010) studied the effect of ICT use in computer students in the Programming Languages course. Students with higher grades in previous school periods, obtained better performances, but authors did not find a significant statistical correlation between ICT use and grades.

Chasco, Pumarada & Contreras (2017) conducted a study interviewing 141 secondary school students in the specialty of Social Sciences where they inquired about the various factors that affect academic performance, including ICTs. One of the conclusions reached was that ICTs' impact on academic performance is negative outside the classroom, and that there is

no significant correlation between academic performance and ICT use in the class.

Educational software is a type of ICT and a pedagogical resource with growing predominance in both basic and higher education institutions. According to García & Hernández (2013), the use of educational software brings interaction and flexibility to the learning process, and also increases students' motivation and cognitive development of the student.

Several educational softwares to improve the learning of logic have been developed, however, they meet the specific requirements of each institution. Such is the case of a tool from the Open University of Catalonia (UOC) in Spain. The software developed is a tutorial system that facilitates conceptual and practical knowledge and helps students recognize their successes and mistakes, enabling corrective actions. According to Huertas, Mor & Guerrero (2010), interaction and fast and adequate feedback are essential in the learning process in disciplines such as mathematics and logic. Huertas et al. (2010) conducted a research using UOC's tool. A pilot test was carried out in a non-face-to-face Logic course in Computer Engineering. Results were measured and an anonymous survey was applied to 107 students, where 91,58% stated that the software was useful to pass the course, and 80,37% said they learned Natural Deduction through its use. It is worth noting that the students of Computational Logic at the UCAB consider Natural Deduction as the most difficult course.

Another tool for teaching logic was developed at the University of Alicante in Spain. The software is free and is called ADN, which stands for Natural Deduction Assistant in Spanish (*Asistente de Deducción Natural*). It is designed to cover the contents of Quantitative Logic, although it also includes the derivations or arguments of Propositional Logic (Mira & Lorens, 2003). No research was found regarding its effect on academic performance. It is referenced in this study as it addresses the subject matter, it is accessible, and focuses on essential content. It was only used as an additional practice which was not evaluated.

Various educational solutions already developed were investigated. Free distribution programs found on the Internet are mostly of European

(Huertas et al., 2010; Mira & Lorens, 2003) or American (USA) origin (Herzberg, 1997; Menzel & Allen, 2011). However, they are mostly outdated and none are tailor-made for the content and style of Latin Americans, particularly Venezuelans. The idiosyncrasy is different, and even the mathematical terminology and notation varies. Moreover, there is a language barrier, given some programs are developed in foreign languages and lack translations.

Rojas & Suarez (2018) and Becerra (2018) conducted researches using the "Truth Table" software with virtual students from Colombia's UNAD. The program partly addresses content from Propositional Logic, namely, how to interpret a formula through the semantic method of truth tables. Knowledge from that thematic unit of propositional logic was strengthened, achieving better results from students.

Arellano, Nieva, Solar & Arista (2012) conducted a study in the same line of research: They designed, implemented and applied software for teaching and learning structured algorithms. The basic objective of its use is to develop abstraction and algorithmic problem solving, which are basic skills for a computer engineer. Computational Logic is an essential course for the formation of these skills.

Arellano et al. (2012) compared three tools: DFD (Editor and Interpreter of Algorithms Represented in Flow Diagrams), RAPTOR (Rapid Algorithmic Prototyping Tool for Ordered Reasoning) and PSeInt (Pseudo Interpreter). Considering their benefits, software was implemented for students to design algorithmic solutions systematically using flowcharts, detecting possible syntactic and semantic errors in the solution and giving students adequate feedback to correct these errors. Once errors are cleared, the software can run the algorithm to visualize the solution. Arellano et al. (2012) finally applied an instrument to measure satisfaction regarding software use. 93% of the students recognized being motivated to perform activities with the software, and 100% considered it helped them solve problems algorithmically. Benefits also showed in students' grades, where the approval percentage was 19% higher compared to students with no access to the educational software.

Methodology

A quasi-experimental investigation was performed since the sample was not randomly chosen. The group was selected according to students enrolled. The effect of an educational software (independent variable) on academic performance (dependent variable) was studied, considering students' condition (intervening variable).

The research was conducted with all students of the Computational Logic course divided into 4 groups. The control group was made up of sections 001 and 003, and the experimental group, from sections 002 and 004. Professor Gloria Tarrío oversaw sections 001, 002 and 003, and Professor Henry Martínez, of section 004. The experimental group had access to the LógicaUCAB software for two hours per week (five weeks) in a laboratory, while the control group did not. Both groups received the same theoretical-practical lessons.

The population was made up of students enrolled in the four sections of Computational Logic in the March-July 2019 semester. Section 001 had 37 students enrolled, section 002 had 32, section 003 had 39, and section 004 had 43, totaling 151 sampled students.

Only seven students did not take the final exam (4,64%) —five from the control group and two from the experimental group. Therefore, the sample was made up of a total of 144 students. Students who did not take this test dropped out of the course.

The content evaluated in this study is not taught in any previous courses, so students should not have any knowledge on the matter. In these cases, according to sources consulted (Hernández, Fernández & Baptista, 2010; Morales, 2008), it is justified not to perform a pretest. However, since group selection was not random, internal validity must be ensured, verifying group equivalence. Hernández et al. (2010) affirm that groups will be equivalent at the beginning and throughout the experiment, except regarding independent variables; measuring instruments must be equal and applied in the same way.

The uniformity of the control and experimental group was verified by a diagnostic test at the beginning of the period. These results were checked

in addition to their academic indexes from the previous period to verify similarity.

Table 5.1
Sample distribution according to group and student condition. March 2019.

Group	Student condition		Total sample
	New	Repeaters	
Control	26	45	71
Experimental	30	43	73
TOTAL	56	88	144

Note: The final sample of 144 students was composed of 88 repeaters and 56 students new to the course.

To compare group performance at the beginning of the study, the means of both the diagnostic test (control mean = 10,19 and experimental mean = 10,35) and academic indexes (control mean = 10,58 and mean experimental = 10,96) were compared. A Student's t was applied for independent groups. It was possible to verify the variance homogeneity of both groups in the diagnostic test (F = 0,043 and Sig = 0,836) as well as in academic indexes (F = 0,826 and Sig = 0,367).

Table 5.2
Statistical data for each group's results in the diagnostic test and their academic indexes, before treatment

Measures	t	Degrees of freedom	Critical Bilateral Level (Sig)	Confidence interval (95%)	
				Inferior	Superior
Diagnostic test	-0,165	143	0,869	-2,114	1,7910
Academic index	-0,469	143	0,641	-2,043	1,2676

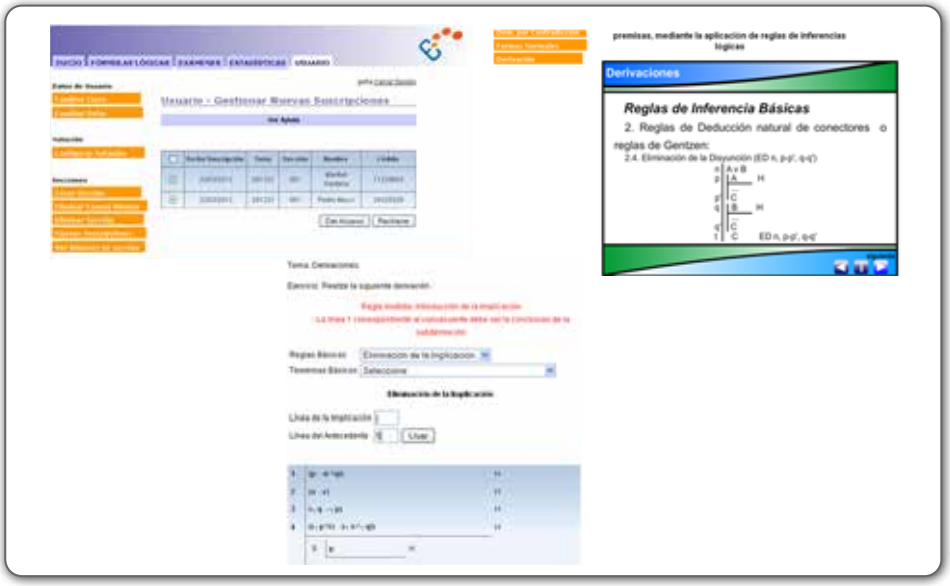
Note: the critical level (bilateral significance) is greater than 0.05, so it can be deduced that there is no significant difference between the means of both measurements.

As ratified by Huertas et al. (2010), in Computer Engineering, the subjects related to logic have characteristics and difficulties like those of other subjects of mathematical nature, such as a very low academic performance and a high amount of dropout. Computational Logic at UCAB is a clear example, because for years it has exhibited a high number of withdrawals and reprobates. To demonstrate this, qualifications in the Computational Logic course from the last four semesters were obtained.

Table 5.3
Record of academic performance in the Computational Logic course.

Semester	Approved		Failed		TOTAL
March 2017	54	44,63%	67	55,37%	121
October 2017	61	46,92%	69	53,08%	130
March 2018	70	46,05%	82	53,95%	152
October 2018	58	48,74%	61	51,26%	119
TOTAL	243	46,55%	279	53,45%	522

Five sessions were planned to cover the entire Propositional Logic content with the use of LógicaUCAB. Figure 5.1 shows its interface.



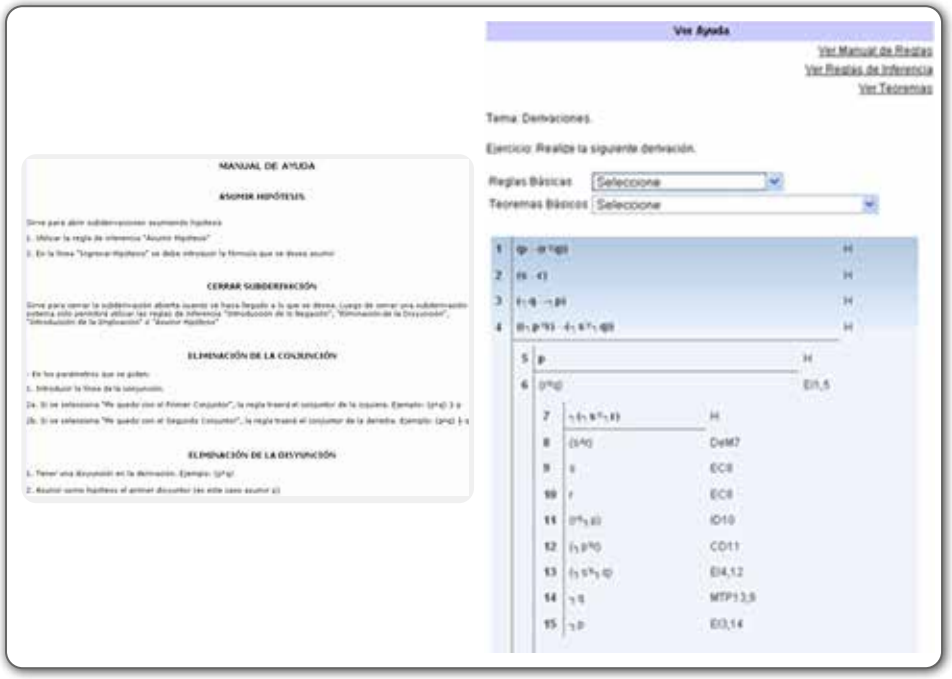


Figure 5.1. LógicaUCAB interface. The user management of the application, a tutorial example, two logical derivation practices, and the help screen are shown.

Given the limitation of the LógicaUCAB use (only in laboratories), it was decided to alternate practice activities using software available on the web called ADN. The activities carried out with ADN were strictly practical. (Figure 5.2).

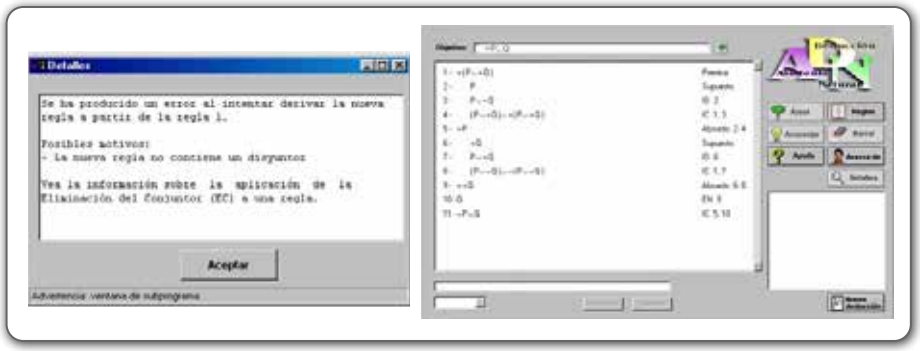


Figure 5.2. ADN Software interface. A software tutorial, an error message, and a logical derivation exercise are shown below. Taken from AND software.

Lastly, to measure the students' academic performance, several virtual tests were carried out using Módulo7-Canvas. Finally, a written test was performed in all sections.

Figure 5.3. Test format in the Módulo7-Canvas platform. A model of instructions prior to a virtual evaluation is showed.

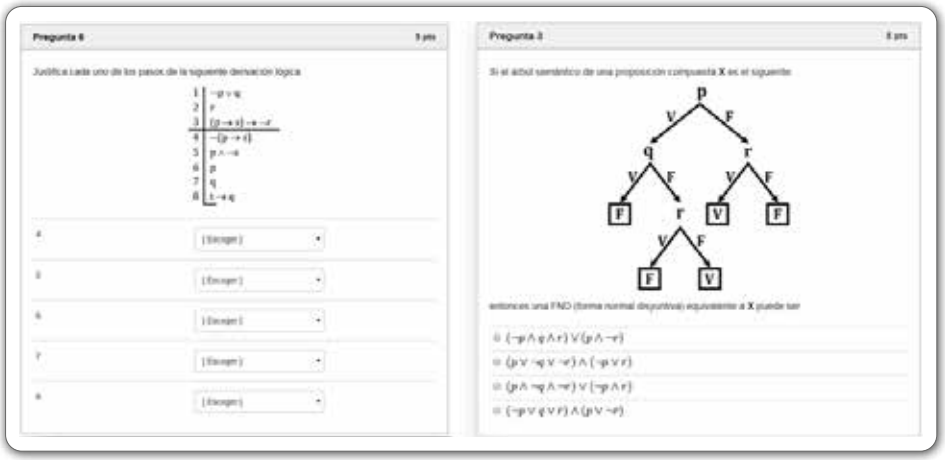


Figure 5.4. Virtual activities in the Módulo7-Canvas platform. Two typical questions regarding the use of inference rules and normal forms are showed.

Figure 5.5. Other virtual activities in the Módulo7-Canvas platform. Two questions for modeling and logical consequence issues are displayed.

Study contribution

For research purposes, academic performance was measured only from quantitative results of the final written test, considering the student's condition (new or repeaters). This variable was considered as in García & Tejedor (2017) study.

To verify the hypotheses proposed in this study on the effect of the use of educational software on student performance and to evidence differences

between the results obtained by the control and the experimental groups in the final written test, means from the qualifications obtained in both groups were contrasted, and variance homogeneity was verified (F = 0,078; Sig = 0,781). A student's t-test was performed for independent samples, where significant evidence was observed at 95% (p = 0,035 <0,05).

Table 5.4
Contrast between the control and experimental groups in the final written test

t	Degrees of freedom	Critical Bilateral Level (Sig)	Confidence interval (95%)	
			Inferior	Superior
-2,131	142	0,035	-3,5268	-0,1321

Note: It is emphasized that only the final written test was considered and not the virtual evaluations, since these tests were not applied to the control group.

Table 5
Statistical data from the final written test obtained by both groups

GROUP	STATISTICS								
	Mean	Median	Variance	Deviation	Min.	Max.	Rge.	Kurtosis	Asymmetry
Control	9.225	8	27.606	5.2541	1	20	19	-0.684	0.544
Experimental	11.055	11	25.497	5.0495	1	20	19	-0.708	0.016

Note: statistical data of the grades obtained in the final written test to compare results between the control and experimental group are showed. The experimental group had an academic average higher than that obtained by the control group (control mean = 9,225 and experimental mean = 11,055).

The maximum and minimum scores obtained by the experimental group were equal to those obtained by the control group, evidencing a high range and dispersion in both groups. In the control group, the mean was greater than the median, which means that the results were asymmetrically biased to the right (9,225> 8). On the other hand, the mean was almost equal to the median in the experimental group, which indicates that the distribution tends to be quite symmetrical (11,055> 11).

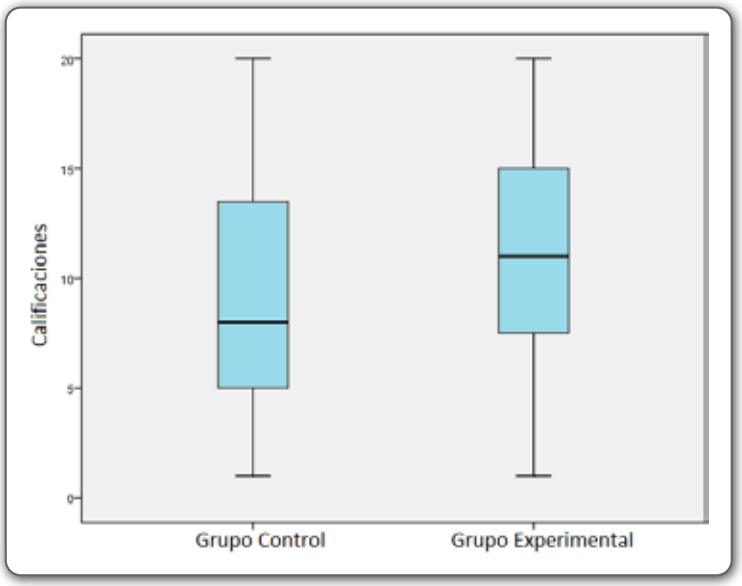


Figure 5.6. Boxplot of the statistical distribution for both groups at the end of the investigation. Most students in the control group achieved low scores in their tests (Asymmetry = 0,544 and Kurtosis = -0,684), while there was a tendency (little concentrated) of scores towards the mean in the experimental group (Asymmetry = 0,016 and Kurtosis = -0,708).

The results obtained offer enough evidence to affirm that the use of the LógicaUCAB educational software had a significantly positive impact on the improvement of the academic performance in the experimental group for the content of Propositional Logic in the Computational Logic course, which confirms the hypotheses formulated. This is consistent with research conducted on the use of support tools for logic subjects, such as the study by Huertas et al. (2010) where a significant percentage of students felt that the use of an educational tool favored their learning and aided in course approval. In Rojas & Suarez (2018) and Becerra's (2018) researches, students improved their performance when using the "Truth Table" software, which makes them further references. The educational tools mentioned in these studies also include some of the content tackled in the LógicaUCAB software.

Results obtained using LógicaUCAB coincide with those obtained by Arellano et al. (2012), where the grades obtained by students who used an

app for teaching algorithmic resolution exceeded those obtained by students who did not have access to technological tools. Han & Shin (2016) also consider ICT use as a determinant of performance.

This study's results are like those obtained by Chasco et al. (2017), since better performance was achieved in the experimental group, yet the software was only accessed in the laboratories of the educational institution, with positive outcomes in student performance. However, these results cannot be generalized to extra-academic situations. Chasco et al. (2017) indicate that the impact is usually negative outside the academic field. Students received guidelines for the use of the ADN tool outside classroom activities during the intervention, yet many students commented that they did not use it since the nomenclature of rules and theorems was different from the syntax established in LógicaUCAB. Its impact was not measured, since it was only suggested for practice outside the classroom.

Although measuring motivation and self-regulation to use the LógicaUCAB or another ICT tool is beyond the scope of this study, it is worth noting that the experience allowed observing that students' attitude toward the content seemed to change: those who used the software appeared to be more interested in attending laboratory sessions; they were more active in asking the teacher questions and completed practical activities with an enthusiasm which was unusual in the course. In accordance with Moreno & Ramírez (2011) and García & Hernández (2013), an increase in motivation, initiative and participation of the student was observed, an aspect which teachers carefully observed. The improvement of grades can be considered a consequence of the student's strong motivation.

The teachers' role in this study cannot be overlooked, considering the exhaustive planning of activities and the role they have in teaching their students how to use the software. Practical activities carried out with the software in the laboratory were organized in such a way that students had clear guidelines at the time of carrying out the activity; exercises were built on a complexity scale, and the student was quickly evaluated and received timely feedback. This idea coincides with Gomez et al. (2011), as well as with Botello & López (2014) and Gil (2012), cited in García & Cantón (2019), and Torres-Díaz et al. (2016), cited in García & Cantón (2019),

who established that academic performance depends not only on ICT use but also on the efficiency of the teaching strategies selected and the correct application of the technological tools in the educational field.

García & Tejedor (2017) point out that students who valued ICT use the most obtained the best grades. According to sampled students' opinions at the beginning of the semester, most considered that software use was going to be of help, however, seven remained skeptical. In fact, five of these students obtained the best scores, and, therefore, no evidence was found of what was expressed by García & Tejedor.

As a product of this study and based on the results obtained, a program was designed for teachers and students to have a practical guide for activities to be carried out with ICTs (educational software, ADN and Módulo7- Canvas) in the teaching and learning process of the Propositional Logic content of the Computational Logic course. This program contains the competences to be developed, contents, necessary resources, and activities for each lesson, as well as tests and an assessment instrument. This program is detailed in the Annexes.

References

Albarrán Peña, J. (2019). La deserción estudiantil en la Universidad de Los Andes (Venezuela). *Educación y Humanismo*, *21*(36), 60–92. https://doi.org/10.17081/eduhum.21.36.2806

Arellano, J., Nieva, O., Solar, R., y Arista, G. (2012). Software para la enseñanza-aprendizaje de algoritmos estructurados. *TE & ET: Revista Iberoamericana de Tecnología En Educación y Educación En Tecnología*, *no. 8*(8), 23–33.

Becerra, L. (2018). *Fortalecimiento de las competencias lógico matemáticas, a través de Truth Table, como parte del requisito para el acceso a la educación superior para estudiantes de grado once, en la Institución Policarpa Salavarrieta Puerto Salgar, Cundinamarca*. Universidad Nacional Abierta y a Distancia-UNAD Escuela Ciencias de la Educación-ECEDU.

Botello, H., y López, A. (2014). La influencia de las TIC en el desempeño académico: evidencia de la prueba PIRLS en Colombia 2011. *Academia y Virtualidad*, *7*(2), 15. https://doi.org/10.18359/ravi.315

Chasco, C., Pumarada, M., y Contreras, J. (2017). Papel de las TIC en el Rendimiento académico : una aplicación con modelos de ecuaciones estructurales. *In Juan Cándido Gómez- Gallego, María Concepción Pérez-Cárceles, Laura Nieto Torrejón (Eds) Investigaciones de Economía de La Educación, Asociación de Economía de La Educación*, (March 2018), 449–471.

Dubon, E., Navarro, J. C., Pakhrou, T., Segura, L., y Sepulcre, J. M. (2013). Estudio de las deficiencias matemáticas en los estudiantes de nuevo ingreso. In *La producción científica y la actividad de innovación docente en proyectos de redes / coord. por José Daniel Álvarez Teruel, María Teresa Tortosa Ybáñez, Neus Pellín Buades,* (pp. 2717–2730). Retrieved from https://dialnet.unirioja.es/servlet/extart?codigo=6031504

García-Martín, S., y Cantón-Mayo, I. (2019). Uso de tecnologías y rendimiento académico en estudiantes adolescentes. *Comunicar*, *27*(59), 73–81. Retrieved from http://10.0.15.76/C59-2019-07%0Ahttp://aplicacionesbiblioteca.udea.edu.co:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=135701878&lang=es&site=eds-live

García-Valcárcel, A., y Hernández, A. (2013). *Recursos tecnológicos para la enseñanza e innovación educativa*. Retrieved from https://www.sintesis.com/biblioteca-de-educacion-145/recursos-tecnologicos-para-la-ensenanza-e-innovacion-educativa-libro-1740.html

García-Valcárcel, A., y Tejedor, F. J. (2017). Student perception of the value of ICT's in their learning strategies and their relation to performance. *Educacion XX1*, *20*(2), 137–159. https://doi.org/10.5944/educxx1.19035

Gomez, D., Oviedo, R., y Martinez, E. (2011). Factores que influyen en el rendimiento académico del estudiante universitario. *Educación y Humanidades*, *V*, *Nº 2*(junio 2011), 8.

Han, I., y Shin, W. S. (2016). The use of a mobile learning management system and academic achievement of online students. *Computers and Education*, *102*, 79–89. https://doi.org/10.1016/j.compedu.2016.07.003

Hernández, R., Fernández, C., y Baptista, P. (2010). *Diseños de Investigación. En Metodología de la Investigación* ((5a. ed.)). México D.F.: México: Mc Graw Hill.

Huertas, M., Mor, E., y Guerrero, A. (2010). Herramienta de apoyo para el aprendizaje a distancia

Martínez, R., y Heredia, Y. (2010). Tecnología educativa en el salón de clase. Estudio retrospectivo de su impacto en el desempeño académico de estudiantes universitarios del área de Informática. *Revista Mexicana de Investigación Educativa: RMIE*, *15*, 371–390.

Melo Fiallos, D. F., Silva Chávez, J. A., Indacochea Mendoza, L. R., y Núñez Campaña, J. H. (2017). Tecnologías en la educación superior: políticas públicas y apropiación social en su implementación. *Revista Digital de Investigación En Docencia Universitaria*, *11*(1), 193–206. https://doi.org/10.19083/ridu.11.498

Menzel, C., y Allen, C. (2011). Daemon Proof Chequer [Software y manual de cómputo]. Retrieved August 29, 2019, from https://logic.tamu.edu/

Mira, S., y Lorens, F. (2003). ADN Asistente de Deducción Natural [Software y manual de cómputo]. Retrieved August 29, 2019, from http://www.dccia.ua.es/logica/ADN/

Morales, P. (2008). *Estadística aplicada a las ciencias sociales*. Madrid, España.: Editorial Universidad Pontificia Comillas Publicaciones.

Moreno Ruíz, M. O., y Ramírez Romero, J. L. (2011). Conocimiento y uso de las tecnologías de la información y la comunicación desde la perspectiva de los estudiantes universitarios y factores que inciden en ellos. *XI Congreso Nacional de Investigación Educativa*, 1–10. Retrieved from http://www.comie.org.mx/congreso/memoriaelectronica/v11/docs/area_07/1912.pdf

Pérez, M. V. V., Castellanos, M. V., Díaz, A. M., González-Pienda, J. A., y Núñez, J. C. (2013). Dificultades de aprendizaje en estudiantes universitarios de primer año. *Atenea*, (508), 135–150. https://doi.org/10.4067/S0718-04622013000200010

Rojas, L., y Suarez, L. (2018). Estrategia didáctica de aprendizaje de la lógica matemática para estudiantes virtuales a través del apoyo de la herramienta tic "Truth Table." *Investigacion e Innovación En Ingenierias*, *6*(2), 78–88. https://doi.org/10.17081/invinno.6.2.3114

Silva, M. (2011). El Primer Año Universitario. *Perfiles Educativos*, *33*(0185-2698), 102–114. https://doi.org/10.1016/S0185-2698(14)70629-4

Annexes

Program for Propositional Logic activities

A detailed program was created with activities to serve as a guideline for future academic periods aiming to improve students' learning process.

General data of the program	
Institution:	Universidad Católica Andrés Bello (UCAB)
Unit:	Faculty of Engineering, Computer Engineering Department
Course:	Computational Logic
Year, semester o teaching period:	Second semester
Content:	Propositional Logic
Activity objective:	Apply the educational software LógicaUCAB and other ICTs
Modality:	Partially online. Face-to-face activities were carried out in the classroom and practical activities in a laboratory with the LógicaUCAB software. In addition, the official UCAB platform (Módulo7-Canvas) and free ADN software are used to apply virtual practices.
General description:	Computational Logic provides the basis for developing algorithmic thinking necessary for computer engineers. According to the current program (October, 2018) of the UCAB's School of Computer Engineering: The Computational Logic curricular unit encourages the development of logical reasoning in students, so that they acquire an adequate capacity for formulation, argumentation and problem solving, essential in the academic and professional area of a Computer Engineer. Reasoning ability is fundamental for personal and professional life, since analyzing, selecting, demonstrating and refuting are essential in the successful performance of a human being and therefore also promotes the integral training of professionals with greater analysis capacity for problem solving. Jobs as programming and software development are creative processes that require abstraction, the construction of formal specifications and the ability to reason. Computational Logic contributes to the development of these skills.

General data of the program	
Didactic context	The activities are oriented towards the learning of the Propositional Logic content. Face-to-face activities are developed in the classroom and some practices are carried out in laboratories using the LógicaUCAB software. Activities are also carried out online, through UCAB's Módulo7-Canvas platform (m7.ucab.edu.ve) where the necessary resources for learning are included, even virtual evaluations. Some tools available on the web (ADN) are additionally used. The objective is to build a collaborative space between students and teachers.
Duration:	5 weeks

Sessions for the application of the LógicaUCAB Software

During the five laboratory sessions, emphasis was placed on the contents considered of greater difficulty according to the results of the applied survey, which are the topics evaluated in the first partial examination of the course. Evaluation activities were carried out using the Módulo7-Canvas platform. The competences to be developed, the contents and the activities carried out in each of the sessions are detailed below:

SESSIONS FOR THE APPLICATION OF THE LógicaUCAB SOFTWARE						
SESSION	**COMPETENCIES**	**CONTENT**			**ACTIVITIES**	**MEANS AND RESOURCES**
		Conceptual	**Procedural**	**Attitudinal**		
1	**Basic competency:** **Learn to learn with quality:** Abstract, analyze and synthesize information. **Professional competency:** **Models to support decision making:** Mathematically models real situations to support decision making	Introduction to Logic Semantic Techniques for the interpretation of logical formulas (Tables of Truth and Semantic Trees).	Uses vocabulary appropriately Models textual content in a formal logical language Evaluates if a formula is well formed Applies semantic techniques to determine interpretation	Values the importance of formal language in logic	The teacher registers a test section in the software and includes exercises and exams in LógicaUCAB. The student registers as a user in LógicaUCAB and the teacher authorizes it. The teacher briefly introduces the software for students to become familiar with its use.	Laboratory with the following tools: MySQL (version 5.0.51b), Symfony (version 1.1.6), Apache (version 2.2.8) and PHP (version 5.2.6). LógicaUCAB educational software.

SESSIONS FOR THE APPLICATION OF THE LógicaUCAB SOFTWARE						
SESSION	COMPETENCIES	CONTENT			ACTIVITIES	MEANS AND RESOURCES
		Conceptual	Procedural	Attitudinal		
1					The teacher invites students to review the tutorials found in the software to reinforce the theory seen in class. The following topics were reviewed: definition of logic, proposition and reasoning, logical modeling, logical connectors and semantic techniques, in particular, truth tables and semantic trees. An exercise is performed to determine the validity of a formula by using two semantic techniques: truth table and semantic tree. The teacher encourages a debate where students compare each of the techniques used. Virtual evaluation activities are assigned in Módulo7-Canvas (laboratories and homework).	Módulo7-Canvas (m7.ucab.edu.ve) Video Beam
2	**Basic competency:** **Learn to learn with quality:** Abstract, analyze and synthesize information. Identify, pose and solve problems	Semantic techniques for the interpretation of logical formulas. (Demonstration by contradiction) Logic demonstration techniques	Represents reasoning as a logical formula Applies semantic techniques to determine interpretation	Actively participates in the resolution of the exercises Uses software recommendations and shows interest in reaching the solution	The teacher records two reasoning modeling exercises in LógicaUCAB. One of these reasonings must be valid and the other not. The student uses the tutorial to review the concept of reasoning and its modeling.	Laboratory with the following tools: MySQL (version 5.0.51b), Symfony (version 1.1.6), Apache (version 2.2.8) and PHP (version 5.2.6). LógicaUCAB educational software.

SESSIONS FOR THE APPLICATION OF THE LógicaUCAB SOFTWARE						
SESSION	COMPETENCIES	CONTENT			ACTIVITIES	MEANS AND RESOURCES
		Conceptual	Procedural	Attitudinal		
2	**Professional competency:** **Models to support decision making:** Mathematically models real situations to support decision making.		Handles Fitch's method as a representation of the derivation Knows and properly applies basic inference rules		The student, using the software, applies the semantic technique of demonstration by contradiction for both reasoning, determining its validity. The teacher instructs students to introduce an exercise selected by them into the software. The student solves it using demonstration by contradiction. The teacher publishes exercises in the software, so that they are visualized by the whole group of students. Finally, the student derives the valid reasoning, using the educational software, with the exclusive use of basic inference rules. Virtual evaluation activities are assigned in Módulo7-Canvas (in laboratories and homework).	Módulo7-Canvas (m7.ucab.edu.ve) Video Beam
3	**Basic competency:** **Learn to learn with quality:** Abstract, analyze and synthesize information. **Professional competency:** **Models to support decision making:** Mathematically models real situations to support decision making.	Logic demonstration techniques	Handles Fitch's method as a representation of the derivation Knows and properly applies the basic inference rules Knows and properly applies the theorems	Uses software recommendations and shows interest in reaching the solution Is committed to the resolution of exercises and interacts with the software autonomously	The teacher proposes an exercise of logical derivation of easy resolution: a valid reasoning previously registered in the software. The student makes use of the interactive aids provided by the software and concludes in two ways: using only basic inference rules and using basic inference rules and theorems. The student selects two derivation exercises from those registered in the software, both classified as medium difficulty.	Laboratory with the following tools: MySQL (version 5.0.51b), Symfony (version 1.1.6), Apache (version 2.2.8) and PHP (version 5.2.6). LógicaUCAB educational software. Módulo7-Canvas (m7.ucab.edu.ve) Video Beam

SESSIONS FOR THE APPLICATION OF THE LógicaUCAB SOFTWARE						
SESSION	COMPETENCIES	CONTENT			ACTIVITIES	MEANS AND RESOURCES
		Conceptual	Procedural	Attitudinal		
3					Using the interactive aids and suggestions given by the software, the student makes the derivation using basic rules and theorems. The teacher explains and proposes homework practices using ADN software. Virtual evaluation activities are assigned in Módulo7-Canvas (in laboratories and homework).	
4	**Basic competency:** **Learn to learn with quality:** Identify, pose and solve problems **Professional competency:** **Models to support decision making:** Mathematically models real situations to support decision making.	Logic demonstration techniques	Handles Fitch's method as a representation of the derivation Knows and properly applies the basic inference rules Knows and properly applies the theorems	Uses software recommendations and shows interest in reaching the solution Is committed to the resolution of exercises and interacts with the software autonomously	The teacher proposes valid reasoning to make the logical derivation with high difficulty. The student makes the logical derivation using the aids and interactive recommendations of the software with the freedom to apply basic inference rules and / or theorems. Students select two derivation exercises from those registered in the software (medium or high difficulty). Students make the derivation using the interactive aids and suggestions given by the software, using both basic rules and theorems. The teacher explains and proposes homework practices using ADN software. Virtual evaluation activities are assigned in Módulo7-Canvas (in laboratories and homework).	Laboratory with the following tools: MySQL (version 5.0.51b), Symfony (version 1.1.6), Apache (version 2.2.8) and PHP (version 5.2.6). LógicaUCAB educational software. Módulo7-Canvas (m7.ucab.edu.ve) Video Beam

SESSIONS FOR THE APPLICATION OF THE LógicaUCAB SOFTWARE						
SESSION	COMPETENCIES	CONTENT			ACTIVITIES	MEANS AND RESOURCES
		Conceptual	Procedural	Attitudinal		
5	**Basic competency:** **Learn to learn with quality:** Identify, pose and solve problems **Professional competency:** **Models to support decision making:** Mathematically models real situations to support decision making.	Logic demonstration techniques. Simplification of formulas. Semantic method for obtaining normal forms.	Handles Fitch's method as a representation of the derivation. Knows and properly applies the basic inference rules. Knows and properly applies the theorems. Gets the CNF and DNF of a formula using truth tables. Verifies the equivalence of normal forms with the original formula.	Uses software recommendations and shows interest in reaching the solution. Is committed to the resolution of exercises and interacts with the software autonomously.	The teacher selects a derivation of high complexity from those registered in the software to finalize the content regarding derivations. Students execute the logical derivation, concluding in several ways, either using basic rules, theorems or a combination of both. The teacher asks not to use the interactive aids provided by the software. The teacher encourages a debate among students about the referral techniques used in the resolution of the exercise. Students select and perform formulas simplification exercises using the semantic method to obtain the conjunctive normal form and the disjunctive normal form of at least two exercises recorded in the software. The teacher explains and proposes homework practices using ADN software. Virtual evaluation activities are assigned in Módulo7-Canvas (in laboratories and homework).	Laboratory with the following tools: MySQL (version 5.0.51b), Symfony (version 1.1.6), Apache (version 2.2.8) and PHP (version 5.2.6). LógicaUCAB educational software. Módulo7-Canvas (m7.ucab.edu.ve) Video Beam

Evaluation activities

The evaluation activities carried out in each laboratory session are detailed below. A written test was carried out at the end of the planned sessions. It is important to note that the percentage of evaluation for the topic Propositional Logic represents 30% of the total evaluation of the subject. The program evaluation plan is detailed below.

EVALUATION PLAN					
SESSION	**Type of test**	**Techniques and instruments**	**Evaluation criteria**	**Evidence**	**%**
1	Formative and summative	Virtual evaluation of simple selection, multiple selection and true / false items through Módulo 7-Canvas	Identifies propositional variables from a text Verifies the interpretation of a formula	Online test	2%
2	Formative and summative	Virtual evaluation of simple selection, multiple selection and true / false items through Módulo 7-Canvas	Builds a formula from a text Uses semantic techniques appropriately Knows basic inference rules	Online test	2%
3	Formative and summative	Virtual evaluation of simple selection, multiple selection and true / false items through Módulo 7-Canvas	Applies basic inference rules Knows the theorems Applies theorems properly	Online test	2%
4	Formative and summative	Virtual evaluation of simple selection, multiple selection and true / false items through Módulo 7-Canvas	Applies basic inference rules Knows the theorems Applies theorems properly	Online test	2%
5	Formative and summative	Virtual evaluation of simple selection, multiple selection and true / false items through Módulo 7-Canvas	Applies semantic techniques to obtain the normal forms of a formula	Online test	2%
FINAL	Summative	Face-to-face written assessment with its corresponding evaluation instrument	Performs logical modeling Makes derivations by applying basic inference rules and theorems. Reduces a formula in its equivalent Conjunctive and Disjunctive Normal Form.	Written test (on campus)	20%

The written test is done in departmental form, that is, it is the same test for all groups taking the course. The evaluation instrument used can be seen below:

Evaluation instrument		
Criteria	**Content**	**Score**
Handles Fitch's method as a graphic representation of logic derivation	Format and readability	1
	Uses subderivations	1.5
	Uses the rules and theorems	1.5
Mathematically models a problem using formal logical language, whether propositional or first-order approaches	Mathematically formulates the established problem	1
	Evaluates if the logical formula is well constituted according to the vocabulary	1
	Identifies reasoning	1
Proves valid performance in a structured and formal way using basic rules of inference and theorems	Knows the basic inference rules	1
	Knows theorems	1
	Applies basic inference rules and theorems	2
	Obtains valid reasoning conclusions	4
Simplifies a formula by obtaining the conjunctive normal form (CNF) and the disjunctive normal form (DNF)	Properly applies a semantic or syntactic method to obtain the CNF and the DNF	2
	Gets the CNF and DNF at its lowest expression	2
Compares the theorems with the algorithmic structures	Compares a theorem with an algorithmic structure	0.5
	Values logic use in the development of algorithmic thinking	0.5

Chapter 6

Integration of ICTs in reading and writing teaching and learning in college

Claudia Salazar[1]

Abstract

This chapter reviews the current incorporation of Information and Communication Technologies (ICT) in colleges, specifically in the area of reading and writing, as compiled in a series of studies published between 2013 and 2019. The purpose is to compare those results with the Guidelines for learning and teaching aimed at improving student performance in the course Reading Comprehension and Writing at the Andrés Bello Catholic University (UCAB). Such guidelines are the result of an investigation carried out as a master's degree Project, "The written composition of argumentative texts in novice-students and teacher-experts" (Salazar, 2018). This link contributes to the enrichment of teaching-learning strategies for reading and writing, by concluding that ICTs can be incorporated for teacher training, teaching in real situations, establishing the "Draft Policy", the definition of explicit evaluation criteria, the execution of mentoring programs, and the dissemination of tools to prevent or confront procrastination.

Keywords

Teaching, learning, reading, writing, university, college, ICT

Introduction

Critical reading and writing are fundamental in tertiary education, since they help to achieve academic processes of quality

that promote the integral formation of students. Manning, Taborda & Polo (2016) state that thinking about reading and writing means rethinking oneself, given these are two pillars of all integral and conscious learning.

The teaching experience in the UCAB's Faculty of Law has confirmed a concern expressed by professors, both in council meetings and training courses: the low performance level of many students regarding reading comprehension and writing. This is also a consistent concern in the case of the Reading Comprehension and Writing course.

This issue has been addressed in several investigations, one of which serves as the foundation for this essay. It offers a guideline to favor the teaching and learning of written composition, in the UCAB's Reading Comprehension and Writing course, a transversal subject at the university. These notions will serve as a reference to review the current status of ICT use for both processes, comparing the conclusions obtained with the established guidelines.

It is hereby relevant to remember the words of Burgos, Rodríguez, Piñeros & Moreno (2018), who stated that learning requires more than the ability to capture the main idea of texts, but rather that it needs the constant elaboration of a certain lifestyle that engenders more authenticity to the conditions of life, that provides more inner peace and freedom.

To generate greater educational possibilities, ICTs should be incorporated in the teaching of reading and writing, since it is essential to promote such a lifestyle, to have a trained society able to access information, evaluate critically, organize and communicate through multiple channels and everchanging formats (Mon & Cervera, 2013).

Although the incorporation of technology inside and outside the classroom is promoted to create diverse educational spaces, Burgos et al.'s (2018) consideration on the function that technique, technology and science have had must be used as a premise: returning to the Greeks' ideas, they are a series of human practices that help an individual become master of themselves and improve their quality of life. Technet (*τεχνη*), originally, was

conceived as the art of living that sought to elevate the human condition to go beyond the ordinary occupations of life.

Therefore, the intention to use technology to improve the quality of life involves using it acutely to promote reading as a habit and writing as a process, as they are both central in any educational activity and in the development of human potential. Molina, Castro, Martínez & Angulo (2018) point out that the main characteristic of a higher education teacher who wants to follow the continuous assessment model is innovation. These authors affirm that teaching and assessing students' learning should not only focus on their storage ability, but that it should rather promote an environment in which student diversity can be appreciated and cared for under an education model that allows students not only to acquire knowledge, but to be a participant in its construction by exercising their knowledge, skills, talents and behaviors to become the professionals that society needs.

The methodology used is documentary, compiling research published between 2013 and 2019 on the integration of ICTs in reading and writing teaching and learning at college level. The results are framed in each of the guidelines defined in the research used as a reference.

"Análisis de la ejecución de la composición escrita de textos argumentativos en estudiantes-novatos y docentes-expertos de la carrera de Derecho[2]" (Salazar, 2018), and was intended to propose guidelines for learning and teaching aimed at improving student performance in the Reading Comprehension and Writing course.

This information organization provides guidance for the promotion of teaching-learning by including ICTs in: teacher training, education in real situations, the establishment of the "Draft Policy", the definition of explicit criteria for evaluation, the development of writing tutoring programs, and the dissemination of tools to prevent or confront procrastination.

[2] *Analysis of the execution of the written composition of argumentative texts in novice-students and teachers-experts in Law School*

ICTs integration in reading and writing teaching-learning in the University: state of the art

ICTs in the University

The investigations reviewed date from the time period of 2013 to 2019, however, the integration of ICTs in the UCAB has been a subject of discussion for far longer. This is evident on Benvenuto's 2003 article, "*Information and communications technologies (ICT) in university teaching*", where the author states that ICTs do not educate or replace the teacher by themselves, yet they are a powerful resource whose incorporation must consider new teacher roles, new content, programs, and evaluation practices. They are an extraordinary enabling mean to design learning environments and to materialize a type of constructivist learning. From a basic thematic core, it is possible to build lessons through collaboration and contributions from both content and experiences that are provided through collaborative networks (Benvenuto, 2003).

A decade later, Herrero (2014) continued this line of research in "*The role of ICTs in university for the training of skills in students*". The results from a qualitative research gather the opinion of elementary students of a Spanish university. According to the study, students use ICT, specifically a platform called Moodle, in accordance with teacher demands for content presentations, email and Internet for searches, yet, they are unaware of ICTs' impact on their education (Herrero, 2014). Furthermore, students state that the use of technological resources by teachers has a positive impact on competency building, provided they feel motivated in the classroom. However, they do not consider there is improvement in their learning, nor direct consequence in their performance and academic results, due to orthodox uses by teachers.

Incorporating ICTs in the classroom in a profitable way implies working simultaneously in **teacher training** and in the production of more research that dictates guidelines on how to use ICT in teaching and how to evaluate its use, not only in the university, but also in previous educational levels, aiming to a systemic implementation. González (2015), in his article, *Reading and Writing Practices with ICT in the classroom: notes for future research analyses*, describes how ICTs have been incorporated in

Argentinian classrooms, based on the *Conectar Igualdad* program. The paper argues there is a progressive advancement of digital media that is symptomatic of a profound cultural transformation that has been changing the ways of producing wealth, interacting socially, defining identities, and producing and circulating knowledge.

There is a cultural transformation operating in Latin America and, in order to promote practices where there is a real inclusion of pedagogical strategies that incorporate ICT in the classroom, it is necessary to develop a qualitative-field and ethnographic research that thoroughly observes the constructions of meaning of teaching-learning processes in the classrooms where the model has been incorporated (González, 2015).

This further research proposed by González (2015) is considered necessary in the university context, because of the deep understanding of the practices of construction of meaning that students develop, and their way of linking with written culture is essential for any didactic discussion that seeks to renew teaching and learning practices. The models and strategies adopted to address the pedagogical practice will depend substantially on the reading and writing subjects (students), with their culture and habits, and with the specificity, which is necessary to build knowledge with others (González, 2015).

ICTs in reading and writing teaching and learning at the University

Molina & Salazar (2015) published the article *Reading printed texts in digital format: teachers' first approaches to digital culture in the university*. In it, they describe a previous research called *Initial training in reading and writing: from secondary education to academic performance in higher education*. This study points to the digital reading practices in universities, the difficulties and fears that students and teachers face regarding digital culture.

The authors indicate that the digital culture in the university is in process of growth. They propose reading and writing from an academic literacy model and raise the need to implement and develop real and effective strategies that allow the teacher to appropriate the use of technological tools for students to be an active part of a certain academic

culture (Molina & Salazar, 2015). This demonstrates the need for **teacher training**, since, if this is possible, reading would have new purposes; the reading footprint would always be a writing process, which in the academic field would be about appropriating the specific knowledge of a discipline. These traces would be registered in blogs, wikis and forums in which the proposal would be collective (Molina & Salazar, 2015).

These traces also arise indelibly when they recreate situations that are more like the real professional context, where students will develop once they finish their studies. The authenticity of these evaluations engages the student in fulfilling a meaningful and complex task (Fernández, 2011).

Moral & Arbe (2013) describe a **teaching experience focused on real situations** in their article *A teaching experience on shared reading, reading for pleasure and ICT as a means of communication and creativity: Readers Club*. There, the authors emphasize that, for the planned objectives on promoting critical reading through dialogue and writing as a process, ICTs have become a very important, almost essential tool, given their ability to attract young people (Moral & Arbe, 2013).

Regarding writing as a process, **drafts** are essential for students to constantly write, review, search for new information, modify, and improve their work. This requires time and valuable effort that translates into a product that demonstrates a reflective process.

Manning, Taborda & Polo (2016) review the theoretical advances in teaching these processes and highlight the role of technology in their paper *Reading and writing as an object of reflection and constant intervention in the classroom*. They state ICTs must be included in the teaching of reading and writing, due to the technological transformations that modify human relationships, through which people get involved in new forms of participation and social interaction. They can be seen as didactic tools that intervene in teaching-learning given the large amount of information that can be obtained, when properly selected, that can decisively contribute in the constitution of the worldview of critical and reflective individuals.

Calle (2013), in the article "La evaluación de las habilidades del pensamiento crítico asociadas a la escritura digital[3]", describes the results of the application of an evaluation proposal designed to analyze how critical thinking skills operate and are strengthened with the production of digital texts for which he developed an observation and a self-report instrument.

The observation instrument indicates how critical thinking skills associated with the production of digital texts materialize during a learning situation supported by 2.0 tools (Calle, 2013). This in turn allows the design of learning environments that respond to education and ICT relationships; generate in students other cognitive processes evident in decision-making, problem solving and thought processes (Street, 2013).

On the other hand, the self-report allows students to monitor their critical thinking skills and teachers to make decisions for the design of learning environments supported by ICTs that strengthen thinking skills, the construction of arguments, conclusions and self-regulation, based on the production of digital texts (Calle, 2013).

These instruments demonstrate the importance of having **explicit evaluation criteria** in teaching and learning processes. It is essential to develop instruments for assessing competencies and documenting their trajectory (Fernández, 2011).

With this clear, t is possible to develop ICT supported writing tutoring programs. Cansigno (2014), in the article "Desarrollo de la competencia escrita con el apoyo de las TIC en el contexto universitario[4]", concludes that ICTs favor the establishment of dynamics that improve learning to write in a daily and academic, personal and professional manner; where content, procedures, initiatives and creativity become shared strategies that drive individual as well as collaborative and group work. This occurs frequently in writing workshops.

[3] The evaluation of critical thinking skills associated with digital writing.

[4] "Development of written competence with the support of ICTs in universities".

Writing practices that consider needs, skills, student representations, etc., should be proposed. With ICT support, it is proposed to follow up on online tutoring and on the use of platforms that include educational activities and multimedia devices (Cansigno, 2014).

Chacón-Chacón and Chapetón (2018) talk about such needs in their paper "Trazos para comunidades discursivas académicas y polifónicas: tensiones y desafíos de la lectura y la escritura en la universidad". The authors offer a possible explanation to common **procrastination** among students when preparing to write: It is likely that, for a university student, it is more reliable or feasible to think of writing as an effort to respond to a set of public and social expectations and not as an act of independent genius. In the first case, it is based on shared references, conventions that are in the memory of the community and that are related to the previous knowledge that the student possesses. In the second, they have to rely on their talent or lucidity, which, as is known, in intellectual work usually comes once they have explored many authors and texts, in addition to discussions and dialogues with others about them. The first option offers clues to inference and production processes, while the second routes the rookie into an apparent freedom that, paradoxically, can be paralyzing (Chacón & Chapetón, 2018).

Finally, student's proposals collected by Cansigno (2014) are listed, as they are references for what follows from this research:

1) Motivation could be greater if students could choose their writing topics, had autonomy in free information retrieval, and could multiply their contacts through social networks.

2) Students could improve their writing if they wrote more frequently and if more feedback and systematization were encouraged from the teacher, tutor, and with the support of ICT.

3) Students' vision leads to real pedagogical challenges when considering the teaching-learning conditions of most of the courses: large groups, institutional programming, multiple objectives, heterogeneity in the public served and lack of technological equipment in the institution regarding student demand.

Conclusions

According to the researches reviewed, and in order to meet the stated objective of relating the conclusions obtained with the guidelines for learning and teaching aimed at improving the student performance in the UCAB's Reading Comprehension and Writing course (Salazar, 2018), a transversal, mandatory subject in the entire university, findings are hereby summarized and strategies are proposed in order to encourage reading and writing in all degrees through ICT use.

Once the current status has been reviewed, it is concluded that ICTs can be incorporated into the teaching of reading and writing in the university because, entrenched in proper planning, they become tools for the accompaniment of students by committed real-life situations teachers, who encourages the process writing texts to go through academic discussions required to develop content, draft reviews, which highlights the clarity of assessment criteria and which, in addition, has support for errors, difficulties or limitations.

Defining the guidelines

Each of the aspects that define chapter guidelines and that support the previous statements are summarized below:

Teacher training

Herrero (2014), Benvenuto (2003) and Molina & Salazar (2015) establish the need for teacher training in ICT, given that the use of these resources in an innovative way, which implies changes in the programs and evaluations, from a constructivist approach, motivates students and positively influences the development of reading and writing skills.

Teacher training should guide the use of strategies for internet search (databases, repositories), classification and reading of quality digital information, and the use and design of blogs or wikis. It should also include the use of virtual classrooms in which they participate in the same way as is expected from their students, so they can then coordinate this type of resources, developing the criteria that follow:

Focusing teaching on real situations

Moral & Arbe (2013) offer a valuable example of how to teach focused on real situations describing a club of readers, with a way of operating that is supported successfully in the use of technologies from a pedagogical conception that exalts dialogue as a basis and that promotes critical reading, collaborative writing, discussions, and network interactions. Their results highlight blogs as a tool accepted by students to display their products, find information of interest, keep in touch with the news, and locate training opportunities according to their tastes (Moral & Arbe, 2013).

Establishing the "draft policy"

Moral & Arbe (2013), Manning, Taborda & Polo (2016) and Calle (2013) encourage the use of drafts by promoting digital reading and writing as a reflective process that requires the use of electronic devices, but also the access to information that needs to be filtered and selected in order to build one's own knowledge and to write about it. The actions taken and the products are self-assessed with self-reports, which determine the need or not to rewrite the document considered improvable or "draft". Likewise, the teacher, by having, developing and sharing observation and assessment instruments, can assertively lead the student towards continuous writing improvement.

With clear criteria, the teacher can use email or virtual classrooms in order to provide students with feedback on the versions of their assignments and use plagiarism prevention programs on the web to ensure the originality and adequacy with publication standards.

Defining explicit assessment criteria

Naturally, final drafts can reach their expectations when evaluation criteria for writing are clearly established. Calle (2013), when presenting the instruments of observation and self-registration, and Fernández (2011), when highlighting the primary character of them, exalt this element.

Table 6.1
Heading of digital literacies and their components

Digital literacy	
Type	**Components**
Informational	a) Recognize the need for information. b) Locate the information. c) Evaluate the information. d) Organize the information. e) Transform the information.
Technologic	a) Organize and manage hardware and software. b) Manage data in different formats.
Multimedia literacy	a) Understand multimedia messages. b) Prepare multimedia messages.
Communicational literacy	a) Present and disseminate information. b) Participate in digital citizenship.

Note: literacies and components of digital competency are showed, since it synthesizes everything that needs to be valued in reading and writing using ICT. Source: own elaboration from Lanz, 2012, cited in Mon & Cervera (2013, p. 32).

These instruments are shared with students in order to offer clear evaluation criteria, for instance, by email, Google Drive, WhatsApp groups, or folders in virtual classrooms. With the support of the teacher, students must have access and review each criterion in order to promote their achievement. Thus, the student will become more aware of their performance in information web searches, and they will obtain tools to filter the information and use it properly when planning, reviewing and evaluating their own writing according to the guide offered by the instruments provided by the teacher.

Develop writing tutoring programs

Everything mentioned so far comes together with the possibility of student accompaniment through ICTs, group workshops or individual consults in writing tutoring programs (Cansigno, 2014). Prendes (2011) propos in his study on available resources to support the written composition: virtual

classroom, network teaching, classroom technology, electronic tutorials, and open publication of content on institutional websites or blogs.

Work on the dissemination of tools to prevent or confront procrastination

According to Tuckman (2003, cited by Garzón & Gil, 2017) procastination is the tendency to spend time, delay and intentionally postpone something that must be done. Chacón & Chapetón (2018) and Cansigno (2014) establish the challenges that the teacher must face to motivate students to read and write with the use of technology, recognizing that, although they are complex processes, students will derive multiple benefits from them. Therefore, instead of being paralyzing, they should encourage students to carry out the tasks, making use of all the resources available.

Teacher accompaniment is essential, and can be done via email to review drafts, or through Whatsapp groups to answer questions or concerns. It could also incorporate topics in virtual forums, or tips through social networks, tools on how to work with the difficulties which ca be faced, etc. Valarino (1997), Cassany (2005), Cassany, Luna & Sanz (2007) have written prolifically on the topic.

Benefits and risk ICT integration in reading and writing teaching-learning in the University

It is evident that ICTs can be incorporated into the teaching and learning of reading and writing in the university, allowing these processes to be developed in a rigorous and systematic way by complying with teacher training in the innovative use of technology, while working on content planning, teaching and evaluation strategies. All this affects student motivation and their willingness to approach reading and writing texts.

Student disposition is vital, since the benefits they will obtain also depend on their commitment, openness to feedback and discipline; the benefits they may have. These benefits translate into developing the ability to search the Internet in academic databases; having criteria to filter reliable and useful information; having a digital file that allows to classify and retrieve information more easily; having access to reading digital texts and

teaching support to carry out relevant discussions; using social network and e-mail to generate spaces for knowledge construction and peer learning, even considering the obstacles written compositions, for which they can also count on teaching support, either through the mentioned tools or through virtual classrooms; having the possibility of sharing the productions of their authorship on wikis, blogs or social networks.

Yet, it is necessary to warn about the risks or possible negative effects if teacher and student efforts are not properly synchronized. Firstly, it is important that the incorporation of technology in reading and writing in the university follows teacher planning, emphasizing that these are processes that must be systematic and carried out with academic rigor. The role of teachers is to accompany and support, not to complete students' tasks, so they must consequently keep boundaries.

Teachers and students should avoid believing that ICT use will guarantee a better reading comprehension and written compositions on its own. There is an entire system at work in the matter of academic performance, and ICTs are just a single part of it. Students must know the key role that their individual effort plays, and that it is their willingness to improve, strive, read, write and rewrite what determines their success, even if sometimes they feel tempted to attribute their failures or fears to teachers or to ICTs; to resign in the face of the complexity of writing or reading of diverse sources that arise in web searches; to get distracted with valid, but not academic use of social networks or electronic devices, when they are intended for the improvement of reading and writing skills in the university.

References

Benvenuto, A. (2003). Las tecnologías de información y comunicaciones (TIC) en la docencia universitaria. *Theoria, 12*, 109-118.

Burgos, C., Rodríguez, S., Piñeros, I. & Moreno C. (2018). Sobre el uso de la técnica y tecnología en la educación. In J. C. Morales Piñero & S. A. Rodríguez-Jerez (Eds.), *Las TIC, la innovación en el aula y sus impactos en la educación superior* (pp. 13-34). Bogotá: Universidad Sergio Arboleda.

Calle, G. (2013). La evaluación de las habilidades del pensamiento crítico asociadas a la escritura digital. *Revista Virtual Universidad Católica del Norte*, 40, 68-83.

Cansigno, I. (2014). Desarrollo de la competencia escrita con el apoyo de las TIC en contexto universitario. *Fuentes humanísticas*. Universidad Autónoma Metropolitana, Unidad Azcapotzalco, Departamento de Humanidades, *27* (48), 243-255.

Cassany, D. (2005). *Describir el escribir.* Cómo se aprende a escribir. Barcelona, España: Paidós.

Cassany, D., Luna, M. & Sanz, G. (2007). *Enseñar Lengua*. Barcelona, España: Editorial Graó.

Chacón, A. & Chapetón, C. M. (julio-diciembre, 2018). Trazos para comunidades discursivas académicas y polifónicas: tensiones y desafíos de la lectura y la escritura en la universidad. *Signo y Pensamiento*, 37 (73).

Fernández, A. (marzo, 2011). La evaluación orientada al aprendizaje en un modelo de formación por competencias en la educación universitaria. *REDU. Revista de Docencia Universitaria*, 8(1), 11-34.

Garzón, A. & Gil, J. (2017). Gestión del tiempo y procrastinación en la educación superior. *Universitas Psychologica, 16* (3), 1-13.

González A. (2015). Las prácticas de lectura y escritura con TIC en el aula: apuntes para una investigación futura. *Educación, Lenguaje y Sociedad*, *XII* (12), 1-21.

Herrero, R. (julio 2014). El papel de las TIC en el aula universitaria para la formación de competencias en el alumnado. *Revista de Medios y Educación*. Universidad de Córdoba. Centro de Magisterio Sagrado Corazón. Departamento de Didáctica y organización Escolar. *45*, 173-188.

Manning, L., Taborda, O. & Polo, M. (agosto, 2016). Lectura y escritura como objeto de reflexión e intervención constante en el aula. *Palabra*, 16, 212-223.

Molina Bernal, I. A., Castro Cortés, C. C., Martínez Molina, B., & Angulo, S. A. (2018). La evaluación centrada en el aprendizaje: una manera de innovar en las instituciones de educación superior. In J. C. Morales Piñero & S. A. Rodríguez-Jerez (Eds.), *Las TIC, la innovación en el aula y sus impactos en la educación superior* (pp. 83-104). Bogotá: Universidad Sergio Arboleda.

Molina Ríos, J. & Salazar-Sierra, A. (enero-junio 2015). Lectura de textos impresos en formato digital: primeras aproximaciones de los docentes a la

cultura digital en la universidad. *Zona Próxima*, Revista del Instituto de Estudios en Educación Universidad del Norte. *22*, 226-235.

Mon, F. & Cervera, M. (septiembre- diciembre 2013). Competencia digital en la educación superior: instrumentos de evaluación y nuevos entornos. Enl@ce: *Revista Venezolana de Información, Tecnología y Conocimiento*, *10* (3), 29-43.

Moral, A. & Arbe, U. (2013). Una experiencia docente sobre la lectura compartida, la lectura por placer y las TIC como medio de comunicación y creatividad: Club de lectores. *Psicología Educativa*, *19*, 123-126.

Prendes Espinosa, Ma. P. (2011). Innovación con TIC en enseñanza superior: descripción y resultados de experiencias en la Universidad de Murcia. *Revista Electrónica Interuniversitaria de Formación del Profesorado* (REIFOP), *14* (1), 267-280.

Salazar, C. (2018). *Análisis de la Ejecución de la Composición Escrita de Textos Argumentativos en Estudiantes-Novatos y Docentes-Expertos de la Carrera de Derecho* (tesis de maestría). Universidad Católica Andrés Bello, Caracas, Venezuela.

Valarino, E. (1997). *Tesis a tiempo*. Caracas: Equinoccio

Chapter 7

Ethics in educational technology: a perspective in the light of philosophical texts on technique

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Abstract

This chapter refers to hermeneutical research. Its purpose is to reflect on the need for an ethics of technology in its educational use, based on the texts of three contemporary 20th-century philosophers who were interested in the subject of technique: Ortega & Gasset, Heidegger, and Mayz Vallenilla. This review leads to propose seven postulates that are proposed to ethically guide the growing use of technology in the various educational spaces. The postulates are

1. We are humans, not gods;
2. Being prevails above possessing and being useful;
3. Promoting a culture of austerity, not of consumption or discard;
4. The technique is at the service of living;
5. There are fruitful relationships between art, poetry, and technique;
6. Increasingly humane and comprehensive education is urgent;
7. The technique must lead the way to transcendence.

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Keywords
Technique, educational technology, ethics, hermeneutics

Introduction

We live in a globalized, interconnected, changing society that has significantly transformed the planet and which is, at the same time, mediated by technology, that is, by modern technique. The technique is an original task present since humankind took the first steps towards rationality, or can be estimated. It has created a growing gap between people and the rest of the world's creatures, making humans a peculiar species. Ortega & Gasset (2000) said that "without technique, man would not exist and never would have existed" (p. 13) (own translation), a sufficiently incisive and lapidary phrase, to the point that makes human existence depends on it.

It is an indisputable fact that, currently, technology permeates virtually all spheres of human life. It is also evident that it offers multiple advantages in education to enhance teaching and learning: numerous studies worldwide confirm this. It is not surprising that teachers, parents, governments, educational institutions, schools, universities, and students are increasingly betting on technology inside and outside the classroom.

Over the years, educators have been entrusting technology with a good part of our daily teaching work: didactics and teaching, planning, administrative management, certification of learning, research, categorization of teachers and researchers, interaction with the student, etc. Even student performance assessment has been placed in the hands of technology, which poses the question: Shouldn't a fundamental human education element remain marked by teacher subjectivity? It is a debate worth considering.

The assistance of technology to teachers has constantly been growing and promises to keep doing so: first, as a useful and complementary learning resource; secondly, as a fundamental intermediate for learning and teacher-student relations; and thirdly, its exclusive use for learning, which sometimes makes the human teacher dispensable. Regardless, teachers are still needed for those three functions to design, plan, and evaluate. Could

an era come when technology is autonomous and completely replaces the role of the teacher? The question is not far-fetched.

As technology advances, the universe of options to strengthen teaching and learning also increases. This, in turn, highlights the intrinsic limit on the horizon of possibilities. Over time, with technology, anything will be possible in education: there will be no limits to what could be done. In a way, we have entered a new world of infinite possibilities, such as learning through virtual or augmented reality (Extended Reality), to name two recent trends in educational technology.

It is human to think and rethink seriously and responsibly about our actions. It is prudent to set limits to power and unlimited power that technology has been offering us. That is precisely the issue that concerns us in this chapter. What remains in the substrate of what has been said so far is what some philosophers posed as the interrogations of technique. What is the technique? Why does it permeate all our daily lives decisively? We could even ask: How should our relationship with it be? How should we deal with it? All these questions will be specially regarded in the field of education.

There is an ethical stance regarding our relationship with technology or how we should deal with it. "Must be" questions remit to the moral realm, or even still, the world of ethics. According to Camps (2002), "it seems accurate to describe «ethics» as ideas that, regardless of whether they refer to the polis, to society or to the individual, are ultimately a question of duty" (p. 11) (own translation). No matter how much humankind flees from ethical thinking or avoids ethical questions, responsibility for their actions remains inescapable.

For this research, some great philosophers of the 20th century reflected on technique and the technological world were reviewed. Such authors are the Spanish José Ortega & Gasset, the German Martin Heidegger, and the Venezuelan Ernesto Mayz Vallenilla. Although they did not live in the last decade of the 20th century, or in the 21st century, a period of relevant social technification, they managed to foresee what was coming and offered reflections that can be very useful for thinking about ethics educational technology.

The purpose of this chapter is to reflect on the need for an ethics of technology in its educational use, based on the texts of some contemporary philosophers who were interested in the subject of technique during the 20th century. First, the elements that make up the dawn and the context of this research are addressed. The methodological approach that guided the research will then be described. Next, the texts from the mentioned authors and their interpretation are reviewed. The postulates derived from the categories extracted from the analyzed texts and the final discussion are gathered in the final chapter.

The challenge of the technique

Technique is one of those human activities about which everyone seems to have things to say. In fact, it is linked to all sciences, culture, arts, knowledge in general, education, research, military activity, politics, economics, etc. The relationship that humans have with technique dates even from our very genesis and has earned us the denomination, of *Homo Faber* (Bergson, 1959). In the preceding paragraphs we have addressed its close relationship with the world of current education.

And what is technique? Here, it is understood as a genuinely human task through which processes and artifacts are artificially produced, which allow transforming the environment so that it adapts to our needs and interests. Therefore, technique leads people to inhabit the world, as it conditions the environment to our needs. The last historical phase of this human task is modern technology. Technology refers to that same original technique that produces artifacts and processes, but now favored by modern science. Thus, the terms modern technology and technique are here used as synonyms.

Etymologically, technique derives from the Greek τέχνη [techne], which means technique, art, trade, skill. As for the term technology, it is made up of the previous etymology of τέχνη [techne] adding another Greek root, λόγος [logos], which means science, treaty or discipline. Bailly (1993) indicates that the term τεχνολογίά ας (η) [technology] already appears in texts of Cicero, Plutarch and Sexto Empírico, and by then it referred to a "treaty or dissertation on the rules of an art, or exposition of the rules of art" (p. 1924) (own translation). This is interesting because the

word technology appears here with a strong link to art or technique, as it deals with the rules that govern such tasks.

Ortega & Gasset (1941) considered that "Subject to be ardently discussed in the coming years is that of the advantages, the threat, and the limitation of technology" (p. 87). The author began his first lesson of a course developed in the year 1933 at the Summer University of Santander with this statement, which was subsequently published as a text called *Man the Technitian* (Buenos Aires, 1939). It is precisely in this paper where his ideas about this "new and gigantic problem" are developed (Ortega & Gasset, 2000).

It is then worth asking: What happens to technique? Why do we have to discuss it? Why does it hang over us like a gigantic problem? Why has it become a growing concern within philosophy? Why does the legitimacy and neutrality of its function within Western civilization suddenly seem so obvious, and we must write about it, even question it? Why do we decide to use it in education and why do some people object to its use in the classroom? Why is it necessary to pose an ethical responsibility in its use in education?

Both Heidegger (1994a) and Ortega & Gasset (2006a) agree that what has happened with modern technique, with technology, is that previously innocent original technique is being repowered in modernity by the λόγος of science. There is a spiral in which science multiplies the capabilities of the technique and, in turn, the new technique multiplies the possibilities of science. It gives way to a sort of infinity and indeterminacy of possibilities by which all the traditional limits of what man can know, can transform, and exploit are broken. That new λόγος of technology is a rationality prevailing in today's society whereby man becomes aware that he can do what he wants whenever he wants.

When this λόγος of technology makes its respective foray into the educational field, other specific phenomena that similarly become problematic seem to occur. According to Burgos, Rodríguez, Piñeros & Moreno (2018), "science and technology are facts or products that are transmitted to the new generations through education" (p. 16) (own translation), so there is an intrinsic relationship between them, because education perpetuates, transmits the knowledge behind these cultural products.

Sullivan (1983) argues that computers have fascinated us with their efficiency and speed. They impose an instrumental rationality (material cause) on top of the efficient or final cause. It is a runaway technology that remains outside of ethics and moral principles. Franklin (1999) highlights that ICTs have violated the limits of space and time, and have profoundly altered people's relationships with nature, with other people, with their communities, and we may not be prepared for it. Technology is a system, an organization, procedures, symbols, new words, and it is, above all, a new way of thinking that is imposed through it. Hence, we must urgently and seriously think about it.

Gayol & Schied (1997) stress that it cannot be denied that, in technology-mediated distance education, cultural domination of certain groups remains over others due to imperialism, neo-colonialism, marginalization, gender discrimination, ethnic groups and religion, aside from problems of access and technology costs. Teachers have a duty to mitigate this domination through the practice of critical pedagogy, also highlighting indigenous cultures. UNESCO (2013/4) states that the simple introduction of computers or technology in the classroom, is not enough to improve performance and learning. The combination of very varied elements is required, such as teacher preparation.

Likewise, is it not happening in some cases that investment in human resources, in teachers, or in decreasing the number of students per classroom, is even more urgent than investing in ICTs in school? UNESCO indicates that:

> In poorer countries, the availability of ICT infrastructure remains a crucial consideration. Many countries cannot yet support widespread computer-assisted learning because schools lack internet access or, in some cases, even electricity supply. But, given the investment required by poorer countries to ensure that all schools have electricity supply or internet access, the use of ICT is unlikely to be as cost-effective as spending more on teachers to reduce class sizes. (p. 293)

Consider, for example, rural schools and high schools in Latin America and the Caribbean, where, for different political, economic or geographical reasons, electricity grids are still not assured: thinking about the introduction of ICTs in these contexts is still premature. Consider the educational

institutions of the large urban concentrations in Venezuela as well, where repeated power failure and for several hours, prevents the stable use of technology for learning.

Finally, Laudadío (2015) emphasizes that the ultimate purpose of education is to train the person to live fully. To do this, we must go beyond the scientific-technical training traditionally held: instead, "an education in human and moral values that builds young people's confidence, future expectations, and helps each one assume their role in personal growth must be priviledged" (p. 167) (own translation). Privileging moral training along with scientific-technical training will result in a better social life, and therefore, in the formation of a better country.

According to everything said so far, the motivation behind this research is in turn framed by the need to carry out a continuous critical reflection on the teaching practice itself, and also on the need to base this practice on solid ethical principles, especially with regard to the use of educational technology. Burgos et al. (2018), admitting the current influence of ICTs on education, affirm that "pretending to transform education by focusing the whole process on ICT use has debatable consequences, and even more when not, enough considerations have been made" (p. 14) (own translation). This chapter is circumscribed in this direction of contributing to the reflection on ICT impact on education.

Hermeneutics in qualitative research

This is a hermeneutical research in which the texts of 20th century philosophers about technique were reviewed. Accordingly, it subscribes to qualitative research in education, which is conceived as an inductive, interpretive, iterative and recurring process, used when it is necessary to further analyze a problem in order to capture the phenomenon holistically (Pineda & Alvarado, 2008). Within qualitative research, the epistemological theoretical perspective or paradigm to follow is interpretivism, which, for Sandín (2003), "develops interpretations of social life and the world from a historical and cultural perspective" (p. 5) (own translation), distancing itself from the natural sciences that seek to explain rather than understand. Text revision led to understand the meanings that the various authors gave to the problem of technique and to generate ethical postulates for its use.

Along with interpretivism, hermeneutics is also used, a philosophical current that has been conceived as a methodological tradition and a method. Hermeneutics is the art of understanding and interpreting. Throughout history, hermeneuts have sustained the basic importance that language has and has had for man. Within language, it is essential to interpret texts, both spoken and written. Moreover, "interpreting seeks the inner meaning behind what has been expressed, while expressing reveals something inside" (Grondin, 1999, p. 45) (own translation), so in that written language there is always a meaning to look for.

In turn, the importance of written text throughout history to convey culture, the ways of thinking of societies and individuals is also highlighted. For Gadamer (2004), in this interpretation, the fusion of horizons between the reader and the text must occur. That fusion of horizons consists mainly of a dialogue that is established between the interpreter and the text, since language is essentially communication. Then, since both the interpreter and the text have their own horizon of intelligibility, that is, their own visions of the world, their own prejudices, understanding leads to both horizons being founded. Finally, the merger occurs when the meanings of the text transforms the life of the interpreter.

To fulfill the purpose of this research, an analytical reading of the works of the chosen authors was carried out first with the purpose of extracting the categories and elements that were considered valuable to support this theory. It became critical reading that led to take a stand on authors' proposals, and on the subject of technique. Necessarily, the author's own position is influenced by the readings made on the subject.

Piñero & Rivera (2012) indicate that categorization "can be conceived as a way to relate our data to our ideas about them, and according to that, it is a link that we establish between the text or its fragments and the interpretation we make of it" (p. 125) (own translation), for which we use a code or category that identifies it. According to Martínez (2004):

> It includes categorizing or classifying the parts in relation to the whole, describing significant categories or classes, constantly designing and redesigning, integrating and reintegrating the whole and

> the parts, as the material is reviewed and the meaning of each sector, event, fact or data (p. 266) (own translation).

Therefore, it is a process that starts as soon as we begin data collection, that is, to select and then read the texts to be interpreted. Once the interpretative work has begun, in the dialectical coming and going of the parts to the whole and vice versa, not only does the categorization occur, but also the hermeneutical circle that philosophers have proposed.

Martínez (2004) points out a practical procedure for categorization that consists of: 1) Transcribing a protocol information, which in our case consists of the pieces of text to be interpreted, 2) Dividing the contents into portions or thematic units, 3) Categorizing, 4) Assigning subcategories, 5) Establishing category axes, 6) Organizing categories, and 7) Establishing links between categories. An example of the categorization of texts used is shown in the following matrix:

Table 7.1
Model of organization of appointments for categorization

José Ortega & Gasset, *Meditación de la Técnica*. **p. 558**		
Root category	**Categories**	**Quote or text (translated)**
Circumstance Life	Nature Nature reform Supernatural	These are the technical acts, specific to man. The set of them is technique, which we can, of course, define, as the reform imposed on nature in view of the satisfaction of its needs. These, we have seen, were impositions of nature on man. Man responds by imposing a change to nature. Technique is, therefore, the energetic reaction against nature or circumstance that leads to create a new order of nature, supernatural, between it and man.
Interpretation: Ortega offers a definition of technique, highlighting that it is the effort of man to reform nature. By reforming nature, man builds the supernatural that consists of an artificial human world, through which he isolates himself from the natural world. This is in close relationship with other ideas of the author, such as the idea of circumstance and the idea of life. It is also related to the idea of basic needs.		

Note: Matrix by Rojas (2018) based on texts reviewed.

To organize the categories and establish links between them, it was decided to use large topics related to technique, which seeked to collect and compare the texts of the selected authors. These themes are a) What technique is; b) Technique from a historical perspective; c) The dangers and benefits of technique; and d) Attitude towards technique. The main reference texts are: *Meditations on technique*, published as an article in a 1939 book by Ortega & Gasset; *The question of technique* published by Heidegger in 1954; and *University in the Technological World* of Mayz Vallenilla (1974). Without further ado, the texts will be hereby analyzed.

Technique in interpreted texts

a) What is technique: It is a basic question: What is it that we call technique? There are common answers to these questions in previous literature. In the attempt to define it, the authors immediately reveal, not only its very particular definition, but also place it within the thematic concerns.

Ortega & Gasset:

First off, Ortega & Gasset (1941) offers what we could understand as a definition of technique:

> Here, then, we have at last the so-called technical acts which are exclusively human. In their entirety these acts constitute technology, which rnay now he defined as the improvement hrought ahout on nature by man for the satisfaction of his necessities. The necessities, we saw, are imposed on man by nature; man answers by imposing changes on nature. Thus, technology is man's reaction upon nature or circumstance. It leads to the construction of a new nature, a supernature interposed betweenman and original nature (p. 95).

Technique is the reform that man makes to nature to meet his needs. Remember: the natural non-human world, the wild world, is difficult to live. Faced with these difficulties, man responds by changing nature, and turning it into a supernatural. In this paragraph, we can extract some very interesting categories, such as: a) **nature**, which constitutes the world that is given to us, b) **reform to nature**, as a synonym for technique, representing the human action that transforms that initial world given, and finally, c) the **supernatural nature** that man creates from technical action.

Regarding education, technique completely overcomes the barriers of the circumstance, e.g., having a class session online with a teacher located hundreds or thousands of kilometers away. But we can also reflect on the levels of technological dependence in our educational world: it is truly difficult today to be able to educate without having Internet access, a computer, a printer, telecommunications and social networks. These technologies have become increasingly essential for the teaching-learning process.

Heidegger:

Another interesting definition is offered by Martin Heidegger, (1994a) who distances himself from the traditional concept of technique, and rather looks for it in the Greeks:

> But where have we strayed to? We are questioning concerning technology, and we have arrived now at aletheia, at revealing. What has the essence of technology to do with revealing? The answer: everything. For every bringing-forth is grounded in revealing […]
>
> Technology is therefore no mere means. Technology is a way of revealing. If we give heed to this, then another whole realm for the essence of technology will open itself up to us. It is the realm of revealing, i.e., of truth (p. 12).

In the author's search for the essence of technique, Heidegger manages to link it then with the creative potential of poetry (poetry), which is the bring-there-ahead, and with the unveiling or concealing of the truth (*aletheia*). Poetry and truth would be two important categories that arise from his conception of technique. With this linguistic turn, Heidegger manages to clarify a beneficial link between poetry (art), truth and technique. As for *aletheia* (truth), technique is to unhide. But the way to uncover it is the Ge-stell, and that literally has been translated by imposition, device, or also by structure of site or shelf where stocks are collected in a warehouse:

> Enframing means the gathering together of that setting-upon which sets upon man, i.e., challenges him forth, to reveal the real, in the mode of ordering, as standing-reserve. Enframing means that way of revealing which holds sway in the essence of modern technology and which is itself nothing technological (p. 20).

What this term attempts to designate is a kind of impersonal will or a generalized cognitive structure that dominates everything in our time. It is the empire of calculus, which sees everything as an exploitable resource. In sum, it is a technological attitude towards the world that in Heidegger assumes a profound ontological character when inserted into the history of being forgotten (Mitcham, 1989).

Based on Heidegger's definition, three relevant categories can be extracted: ***Ge-stell***, as a site structure, which refers to a mentality that sees every entity in the world as an exploitable resource; to **undisguise** or reveal the occult, which is an ontological category that refers to the truth, in the way of revealing the Being shown in the entities; and finally, **provocation**, referring to the fact that man is provoked or forced to see everything with a technical mentality.

The technical view to which Heidegger refers applied in education could be that which leads us to look only at the quantitative aspects of it, while leaving aside other existential dimensions of the human beings that participate in it. The technical perspective focuses on the parts rather than whole, that is, on technical procedures, the technical conception of teaching, while ignoring educational contexts and needs. This can be evidenced in planning, strategy, evaluation and educational research.

Mayz Vallenilla:

Another relevant author is Mayz Vallenilla (1990), who distinguishes the concepts of technique and meta-technique. Recently, the technique has made a qualitative leap and has become meta-technique, which is the current technique:

> In the face of this modality hitherto prevalent in technique –of anthropomorphic, anthropocentric and geocentric style and limits–, a new project and model of whose logos intends to transform and transcend those limits begins to be suggested in our own time (modifying *eo ipso* [for themselves] the purposes of the traditional technical task), seeking to increase the power available to man beyond the borders imposed by his original somato-psychic constitution and the parallel

> cognitive capacity sustained by it. This is what the author refers to as meta-technique. (p. 15) (own translation).

In this new time of technique, meta-technique has surpassed its human and anthropocentric configuration, to give way to instruments, procedures and, in general, a mentality characterized by limitlessness. Therefore, according to Mayz Vallenilla, they are trans-human and trans-finite instruments that overcome the spatial-temporal optical-enlightenment rationality that had shaped all the Western technique and culture so far. Of course, the ultimate goal of meta-technique is power, granting it increasingly to man, an unlimited force to which people are not used to –atomic energy is a clear example of this.

The categories extracted from these texts are: **domain**, which refers to the will of power man exhibits through technique; **otherness**, which refers to everything other than the self, other men and all other entities in the world; **anthropocentrism** and **anthropomorphism**, which refers to the purposes to which the past technique tended, but whose limits were exceeded with the new technologies; and **geocentrism**, which also referred to the technique of a few years ago where we were confined to Earth.

Mayz Vallenilla (1972) emphasizes that we could be living in an underdeveloped country that continuously receives the technical incentives of an alien post-industrial society. The risk of uprooting our ethos is evident. This regards technological colonialism or technocratic imperialism. It invites educational institutions to train their graduates by warning them. The values with which the current technical rationality aims to train our citizens do not convince us. It is an attitude that opposes the contemplative attitude and respect for the environment, natural to our Latin American continent.

b) Technique in historical perspective: some writings tend to reflect on the development of technique in history. The three chosen thinkers point out that, in modern technology or technique, something worrisome is arising.

Ortega & Gasset:

Ortega argues that there are three major phases in the evolution of technique: 1) The technology of chance, 2) the technology of the craftsman

and 3) the technology of the technician. The technology of chance is characteristic of primitive man and "It does not occur to him that technology is a means of virtually unlimited changes and advances". (1941, p. 143). The second stage is the technology of antique craftsman groups and Middle Ages technique. "It has become necessary for a definite group of people to take them up systematically and make a full-time job of them. These people are the artisans. (p. 146).

The categories that can be extracted from the first phase proposed by Ortega & Gasset are **chance**, ignorance and limitations. The first refers to the fact that the technical action of man is not the result of premeditation but of random discoveries. **Ignorance** refers to man not being aware of the transformation potential in his hands and does not know what the technique is. And, finally, **limitation** means that the technical capacity of man is limited. From the craftsman phase, two categories can be extracted: Specialization refers to the ability derived from people who dedicate their lives to the trade, which makes them specialists. **Skill** is related to craftsmen's technical skill.

The third phase regards the technicians' technique, and describes the moment in which humanity has lived for the past two centuries due to the use of science:

> We have called it «the technology of the technician». Man becomes clearly aware that there is a capacity in him which is totally different from the immutable activities of his natural or animal part. He realizes that technology is not a haphazard discovery, as in the primitive period; that it is not a given and limited skill of some people, the artisans, as in the second period; that it is not this or that definite and therefore fixed "art" but that it is a source of practically unlimited human activity. (pp. 149 – 150).

According to Ortega, this puts man in a «tragicomic» situation: we are aware of the ability we have to achieve whatever we might conceive, yet, we are also terrified of our own potential.

The categories derived are: **Limitlessness** consists in man's infinite capacity for creation through technique, which keeps man troubled for not

knowing what to do with so much power. **Science** refers to the rigorous and methodical knowledge that attempts to establish the laws that govern reality. Finally, the **method** can be understood as a path or set of procedures that are intentionally directed towards a specific purpose.

In this classification, Ortega acknowledges that something has changed in this last technical phase. It is no longer the same as before. Recent use of modern information technologies in education marks an unprecedented milestone in the history of pedagogy and differentiates it from the past: the limits to learning have faded away; learning can take place without barriers, e.g., space or time; there is no need to share the same time or space as the teacher, etc. Over time, machines will be able to fully handle human training, which raises new ethical questions, unthinkable a few decades ago.

Heidegger:

Heidegger also discriminates between periods or phases regarding technique and distinguishes between technique as thought of by the Greeks, artisanal or manual technique, vs. modern technique: "It is said that modern technology is something incomparably different from all earlier technologies because it is based on modern physics as an exact science. (1977, p. 14). Heidegger clarifies there is a fundamental and reciprocal influence between exact sciences or research and modern technique. Furthermore:

> The revealing that rules throughout modern technology has the character of a setting-upon, in the sense of a challenging-forth. That challenging happens in that the energy concealed in nature is unlocked, what is unlocked is transformed, what is transformed is stored up, what is stored up is, in turn, distributed, and what is distributed is switched about ever anew. Unlocking, transforming, storing, distributing, and switching about are ways of revealing (p. 16).

The text makes a claim towards modern technique: man provokes nature, forces it to offer all kinds of resources that are then transformed, stored, distributed and, then, again transformed. With the new technique, the world around, nature, is a warehouse from which resources are acquired in an unlimited way, even if we don't need them.

The categories that are extracted are: **Cultivating**, which is the previous form of technique that consisted of sheltering and taking care of the land. **Science**, which is a rigorous and methodical knowledge, that attempts to establish the laws that govern reality. The Heideggerian category of **provocation** reappears, referring to the fact that man is provoked or forced to see everything with a technical mentality. And, finally, the Heideggerian concept of **unconcealing** or revealing, an ontological category –that is, linked to the problem of Being– which refers to the truth in the way of unveiling the Being shown in the entities.

Heidegger's claim towards the exploitative mentality derived from technology could focus on a lucrative use of educational technology. By cancelling space and time limitations with new learning systems based on information technology, profits have increased, since it is no longer confined to a country, region or language. The legislation that regulates this new way of educational work may not have reached the appropriate maturity to establish the necessary boundaries. Hallak & Poisson (2007) also warn on another example of this exploitative mentality: fictitious universities have multiplied worldwide, giving way to activities such as smuggling of false diplomas, degrees or credentials, which has resulted in educational fraud mediated by technology.

Mayz Vallenilla:

According to Mayz Vallenilla (1990), initially there was the traditional technology:

> Nature was then interpreted as an extension of man himself and his needs. Our possibilities and limits were consistent with it. Therefore, technology assumed an exclusively geocentric significance and its presumed purposes were explained primarily with the help of anthropomorphic and anthropocentric concepts and schemes. (p. 14) (own translation).

The derived categories are: **Optical-enlightenment** and **space-time logos**, that is, a rationale based on anthropomorphic and geocentric categories; anthropomorphism, which indicates that technical artifacts and products are an extension of human capabilities. Another relevant category

is **geocentrism**, which refers to the confinement of technical development to a range of action within our own planet.

Currently, a new rationality or phase is found, called meta-technique:

> One of the most peculiar features of the meta-technique lies in its attempt to create or produce a modality of logos or non-human thinking –trans-human, meta-human– whose forms, laws and principles are not identical or similar to those that inform and sustain human discourse. Not only the variation, modification or alteration of the constitution and functioning of the cognitive sensory of man is used to achieve this purpose, but also their replacement by instruments or devices whose mechanisms and operations can be eliminated or replaced, consequently producing a logos or meta-human thinking –not anthropomorphic, anthropocentric or geocentric– whose correlates form a trans-human and trans-finite otherness. (p. 5 - 6) (own translation).

The new meta-technique, unlike traditional technique, does not have man, nor the human senses, specially sight, as a point of reference, on the contrary, it tries to overcome them. Therefore, the text highlights that its modality is trans-human, meta-human, trans-finite and the rationality or logos that it brings is also foreign to the anthropomorphic.

The categories derived here are: The trans-human or **meta-human logos**, which indicates that the new technique completely transcends the rational and epistemological patterns assigned by man. Similarly, **trans-human and trans-finite otherness** refers to a kind of technical entities that also surpass the traditional canons of man-made objects. All this gives way to a new **trans-reality**, which also far exceeds reality, which we know little or nothing of.

New technology that permeates everything is not simply a new learning resource that was introduced in classrooms. At times, it seems the machine is the classroom, the teacher, the classmate, the text, and the resource. We are then introduced to a new world that we were not used to, a new technological trans-reality. The risk of it getting out of hand is always latent. We will have to take charge of the matter, understand the

phenomenon and build conceptual and procedural tools that allow us to keep control of education in new technology-filled scenarios.

c) The dangers and benefits of technology: The different assessments that the chosen authors have been making regarding the hazards and profits of technology are gathered. That should prompt us to consider that this task is not neutral, and deserves to be thought of.

Ortega & Gasset:

According to Ortega & Gasset (1941) the third phase represents a real danger. Holding on to a single point of view in the matter, rather than understanding the relative meaning of current technology is a big problem:

> I have opposed this tendency and embedded our present technology, as one among many others, in the vast and multiform panorama of human technology in its entirety, thereby relativizing its meaning and showing that every way and project of life has its corresponding specific form of technology. (p. 138).

A wider mindset is needed, and understanding that technology is not everything or the most important thing, as well as avoiding the danger of thinking the human world is the only thing there is: Man humanizes the world, which could become saturated with man, and human offspring could walk on it as we mentally walk now through our intimacy (2006b, p. 537).

Technological transformation on the world is so incisive that we could come to believe that humans are the only things that exist. In fact, lifestyles in the big cities show this. But it is precisely that supernatural nature that saves men, by granting enough resources to face environmental challenges to complete their own life projects.

Some of the categories that can be extracted from Ortega & Gasset's texts are: **Technique relativity**, which implies that Western technique is only one of many possible, and depends on life projects each society has chosen. **Fear**, individual or societies' attitude of suspicion towards the technique. **Claim of antonomasia**, or the belief –common in current wes-

tern thought– that our technology is the only one and the best, whereas it is typically relative. **Alteration or animality**, the risk of living outside oneself. **Supernatural** refers to the artificial world saturated with man that is built by man himself through technique. **Limitedness,** the infinite possibilities of the technique, which can in turn lead to emptiness. **Emptiness**, or the lack of human sense, caused by a life altered by technology. **Comfort**, the supernatural socket that technique offers men to be themselves.

The emptiness, product of the technical mentality, can be denoted in the educational field in didactics, i.e., strategy, planning and evaluating. Teachers use certain technologies driven by trends, peer recommendations or personal attraction towards them, but not because of a serious meditation on the matter, or a conscious diagnosis of students' needs. Teaching is then carried out, but with an emptiness of meaning, devoid of intentions.

Heidegger:

Heidegger (1977) sees a serious risk in the essence of technique, which he describes as:

> Since destining at any given time starts man on a way of revealing, man, thus under way, is continually approaching the brink of the possibility of pursuing and pushing forward nothing but what is revealed in ordering, and of deriving all his standards on this basis. Through this the other possibility is blocked, that man might be admitted more and sooner and ever more primally to the essence of that which is unconcealed and to its unconcealment, in order that he might experience as his essence his needed belonging to revealing (p. 26).

According to this, the danger of unconcealment is the risk of unilaterality, that men take it as the only one possible and chase away other άλήθεια [aletheia, truth] possibilities. Every act of revealing, as a destiny of being, is dangerous, yet, in the case of technology, it can be considered *the peril*. Man is also in danger of losing his roots and his characteristic way of being: living. Technological advances homogenize everything, including the land in which man inhabits, obfuscating the relationship of man with his native soil.

But technology also has benefits: its essence needs to be addressed. If it is taken care of, proximity to danger will make people see the roads that lead to its benefits. Heidegger saw:

> I see the situation of man in the world of planetary technicity not as an inextricable and inescapable destiny, but I see the task of thought precisely in this, that within its own limits it helps man as such achieve a satisfactory relationship to the essence of technicity. (1981, p. 61)

Thought could lead to understand the damages of technological unilaterality and to conceive it, not as an absolute, but as another way to make the truth clear. In this case, the savior of the technique is that the devastating of itself must motivate us to seek solutions. In this case, the technological benefits that rise to the rescue are precisely born from the need to seek solutions in the face of the dangers that technology poses.

The categories derived from this section are: **Unilaterality**, to denote the fact that the technique tends to be affirmed as the only way of truth, or access to the entity. Concealment, since the technique **hides the Being** because it only considers them exploitable entities. **Uprooting**, because the technique tends to destroy the environment, and erases the cultural roots of man. **Thinking**, an activity inspired by technology, which leads people to explore its saving benefits. And, finally, **art and poetry**, related to technique's origin, yet different human expressions in the world.

It is a fact that the use of technology as an ally for education is a phenomenon in today's society, which is practically widespread and increasingly growing. According to Heidegger, perhaps, so that the savior benefits flourish in it, it would be convenient to create spaces of reflection mediated by technology (courses, diplomas, blogs, discussion groups, etc.) specifically dedicated to thinking about its desired use. Spaces in which students and teachers, or staff in general, express their ideas about it, how they feel when interacting with machines, its correct use, etc.

Mayz Vallenilla:

According to Mayz Vallenilla, the problem of techology is eminently cultural, of omni-comprehensive colonialism:

> Technique or the technified existence is a project that homogenizes man, while the world designed is an anonymous and common universe, within which the intramundane entities, including man himself, appear and are seen as appropriate tools. (1974, p. 98) (own translation).

The dangers become evident: with technology, everything becomes homogeneous, including man; everything is anonymous and loses its own worth, its essence, since from then on, the entity is valid because it is a useful instrument for the technification of the universe. Yet, Mayz Vallenilla also considers there is an emerging savior in the current work of science and technology, which has to do with the emergence of a new humanism, universal political. He explains that through the work of science, specifically through technology, the world has become a universal dwelling place of man and the earth as a whole has become the planet we inhabit in common (1967, p. 38).

Technology has not only helped us transform the environment and helped us turn it into our particular habitat, it has also opened out horizons and show us we are inhabitants of all the earth.

Regarding categories, there are: The **homogenization** of man, operated by technique, stripping him of his nativeness and making him anonymous. The **instrumentalization** of the entity and of men, making them a means for the total technification of the universe. The **anonymous universe** built by technical work, causing man to lose his roots and his essence. The **imposition**, while the technique is given to us from the outside, we are not its creators, and we are dependent on it. And finally, the **universal political humanism**, which would be the savior of the technique, because it has pushed us as a species to a greater awareness of the objective and universal value of people.

Regarding homogenization, the technology we use, equipment and software come from cultures outside our own, designed for contexts other than ours, usually elaborated in the English language, as well as most resources available on the Internet. We have no choice but to adapt to the culture where technology originates. Such cultural infiltration takes place

from the very context of the classroom. That is when technology homogenizes us and adapts us all to take the form and aspect of the dominant culture.

d) Attitude towards the technique: It is relevant to read and interpret the authors' recommendations offered on what our attitude towards technology should be, and their recommendations for the human race to face this task, which is the product of our own rationality and doing.

Ortega & Gasset:

Ortega & Gasset invites "to suspend action in order to review our ideas and forge a strategic plan" (2006a, p. 547) (own translation). That is why perhaps at the end of Man the Technician he provocatively suggests that Western culture will have to take more notice of Asian soul techniques:

> But human life is not only a struggle with nature; it is also the struggle of man with his soul. What has Euramerica contributed to the techniques of the soul? Can it be that in this realm it is inferior to unfathomable Asia? Let us conclude our argument with opening a vista on future investigations which would have to confront Asiatic technologies with those of Western civilization (1941, p 161).

An invitation underlies in this thought: to contemplate reality as whole, and acknowledge that man is made of body but also soul. Our current technique has very little to say about the soul. To promote only the material is to stunt human life, which cannot be reduced to the struggle with matter.

The derived categories are: **Self-absorption**, which is the opposite of alteration and consists in suspending pure action to dedicate ourselves to thinking and reflecting on ourselves. **Wholeness perspective**, which regards understanding that the technical outlook is not the only one and that human life dimensions are diverse. **Panoramic and synthetic education** in schools and universities, which tends towards a holistic, trans-disciplinary conception of the phenomena. Finally, **soul techniques**, which invite to look towards other techniques, such as oriental techniques that revalue other dimensions of man, such as the spiritual or religious dimensions.

The divorce between the knowledge acquired and the context has been a problem for several years in various countries. There is no doubt that the search for the link between theory and practice, and for people's integrality will bring numerous benefits to society. Following Ortega & Gasset's idea, as Euramérica should look to other horizons of the world, could it not be that a new way of grasping the technique, more coherent with its original entity, could arise from Latin America?

Heidegger:

According to Heidegger (2001), the fundamental structure of man is «Being-in-the-world», which implies that we have an essential relationship with our surroundings, and that we are that relationship. Resorting to German etymologies, Heidegger finds that "being" is the same as "living", so living is our essential way of being. Therefore, we do technique. People do not inhabit because they have built, rather they built to the extent that they inhabit (Heidegger, 1994b). Technique makes the world inhabitable through building is part of our essence, but that inhabiting is not destructive, on the contrary, it shelters and cares for the world and its people, in its own dynamism. The necessary attitude towards technique then, is the attitude of inhabiting, which is in our own essence.

Heidegger argues that the technical task has not been directed with this attitude of living respectfully of the environment, but with an exploitative mentality. Since technology has become indispensable in current quotidian life, he recommends a more proper attitude: Releasement [*Gelassenheit*]:

> We let technical devices enter our daily life, and at the same time leave them outside, that is, let them alone, as things which are nothing absolute but remain dependent upon something higher. I would call this comportment toward technology which expresses "yes" and at the same time "no," by an old word, *releasement toward things* (1966, p. 54)

Releasement is to know how to accept or deny technology in appropriate amount, not letting ourselves be dragged by it, or that its use becomes inevitable to us.

The prominent categories in this section are: "**Being-in-the-world**", which is our fundamental way of being, of living in the world. To **inhabit**, that is our existence and the way of relating to the world. To **build**, which is the technical action that respects the environment, sheltering it and taking care of it, which leads us to live. And **releasement**, as the attitude of accepting or refusing, or general detachment from technological advances.

Heidegger's releasement proposal becomes more urgent the more we become dependent on technology. For instance, the time spent on a smartphone and its multiple and colorful features, to a point where people can no longer live without it. It is also clear that we have become increasingly dependent on technique in education. Releasement should lead to rational benefits from these technological resources and, at the same time as good teachers, always have a plan B, be prepared for when technology can fail, or when historical-social circumstances lead to a scenario in which suddenly technology becomes unavailable.

Mayz Vallenilla:

For Mayz Vallenilla (1972), man must be characterized by reflexive and critical meditation. Given the novelty of the technique, and at the risk of appearing redundant, we must innovate. He considers this a special task in the field of education; given technology has a very important role training and modeling people. Innovation means to question the technique and the technified education in its own foundations with the express purpose of modifying its effects and projecting the meaning of the formative work towards new paths and horizons, more varied than the pure technical reason prevailing today.

Among the categories that can be extracted from these and other texts are: **Innovation**, which means critically questioning the technique and its novel artifacts, from education. **Interdisciplinarity and Transdisciplinarity**, as a new way of building knowledge in the university and setting hyperspecialization aside. **General and humanistic studies**, a new training in which to prepare professionals to face the complex problems of today's society. **Human dignity**, as the ideal people that must be rescued

by society, as a means to an end that brings technical reason with it. **Understanding**, what is the technique, what is its ontological basis.

It is a serious effort to understand what the technique is, what is its foundation, its essence and where it is going. These reflections are this chapter's invitation in the context of technological uses in the classroom. The purpose would be to find a new ontological foundation for the technique that no longer leads to mere human domination, but to rescue the true value of people. Next, a matrix gathering all extracted categories is shown.

Table 7.2
Synoptic matrix of the categories found

Topic	Ortega & Gasset	Heidegger	Mayz Vallenilla
What technique is	Reform of nature	*Ge-Stell*	Domain
	Supernatural	Provocation	Anthropomorphism
	Nature	Reveal	Otherness
		Poetry	Geocentrism
		Truth	
Technique in a historical perspective	Ignorance	Cultivate	
	Chance		
	Limitation		Anthropocentrism
	Ability		Optical-enlightening logos
	Especialization		Geocentrism
	Science	Science	Trans-human and meta-human logos
	Method	Provocation	Trans-human and trans-finite otherness
	Limitedness	Reveal	Trans-reality

Topic	Ortega & Gasset	Heidegger	Mayz Vallenilla
The dangers and benefits of the technique	Relativity		Anonymous universe
	Fear		
	Claim of antonomasia	Unilaterality	Homogeneization
	Alteration or animality	Concealment	Instrumentalization
	Limitedness		
	Emptiness	Uprooting	Imposition
	Supernatural	Thought	Universal political humanities
	Comfort	Art	
		Poetry	
Attitude towards the technique	Absorption	Being-in-the-world	
			Interdisciplinarity
	Wholeness perspective	Inhabit	Transdisciplinarity
	Panoramic and synthetic education	Building	General and humanistic studies
	Soul techniques	Releasement	Comprehension
			Human dignity

Note: it has been attempted to locate the categories of each author in line with the categories of the other authors with whom it is related. Content by Rojas (2019) based on documentation review.

Ethical postulates

Here, an ethical theory attempting to guide how human relationship with technology should be is outlined. It is a proposal on how technical actions in education should be. This is the fusion of horizons proposed by Gadamer (2004), which is a dialogue established between the interpreter and the text. First, the interpreter recognizes their own horizon in this dialogue, which is their context, training, and concerns. Then, the interpreter tries to decipher the author(s)' horizon, which was carried out in the previous section. Then the dialogue, the fusion, of horizons begins as the

meanings of the text transform the interpreter's life and worldview. This is what Gadamer (2004) calls the application.

The specific way in which this section is structured is through postulates or affirmations. According to Ferrater Mora (2004, p. 2860), Aristotle defined postulates as not universally admitted or self-evident propositions. Unlike axioms, they were rather held in relation to other approaches previously based and denoted no claim to universality.

The categories found in the authors' texts are inspiring or permeating the construction of this theory. In table 7.3, there is a new summary of such categories in connection with the postulate to which they originated. Of course, this will reveal new connections between categories emerging from the texts of different authors.

Note that the distribution of categories used is not proportional or symmetrical, but that it responds to the author's interests as an autonomous researcher, and to the capacity perceived in each category to provide a foundation for the postulates that are being proposed. The postulates are: 1) We are humans, not gods; 2) Being prevails above possessing and being useful; 3) Promoting a culture of austerity, not of consumption or discard; 4) Technique is at the service of living; 5) There are fruitful relationships between art, poetry and technique; 6) An increasingly humane and comprehensive education is urgent; 7) Technique must lead the way to transcendence.

Table 7.3.
Categories that support the postulates

Postulate	Ortega y Gasset	Heidegger	Mayz Vallenilla
We are humans, not gods.	• Limitedness	• Cultivate	• Domain
Being prevails above possessing and being useful.	• Nature	• Concealment	• Instumentalization • Dignity Humana
Promoting a culture of austerity, not of consumption or discard.	• Self-absorption • Alteration or animality	• Releasement	• Understanding

Postulate	Ortega y Gasset	Heidegger	Mayz Vallenilla
Technique is at the service of living	• Nature reform • Supernatural • Comfort • Emptiness	• CBuild • HInhabit • «Being-in-the-world» • Uprooting	• Anthropocen-trism • Geocentrism • Trans-reality
There are fruitful relationships between art, poetry and technique	• Chance • Ignorance • Limitation	• Truth • Reveal • Think • Art • Poetry	
An increasingly humane and comprehensive education is urgent	• Science • Method • Especialization • Claim of antonomasia • Relativity • Panoramic and synthetic education	• Unilaterality • Provocation	• Homogeneization • Interdisciplinarity • Transdisciplinarity • General and humane studies
Technique must lead the way to transcendence	• Absorption • Wholeness perspective • Soul techniques		• Humanism Universal Political • Human dignity

Note: The categories were located in line with the substantiated postulate. Matrix by Rojas (2019) from texts revision.

a) We are humans, not gods: "We are not God. The earth precedes us and has been given to us". Thus, begins paragraph 67 of Pope Francis's (2015) Encyclical Letter *Laudato Si* (Praised be [my Lord]) published. In the context of that phrase, the Pope calls upon humanity, because although according to the Bible, God has asked man to support Him in creation, we are not allowed

to do everything regardless of other beings of nature. We are invited to till and take care of the earth, to protect and make life grow; that is the call to supporte creation.

A first ethical postulate that has seemed pertinent to the technique flows just along that same line. We are human and not gods; not everything is allowed. And there are several categories that emerged from the texts studied that led to this reflection. Some categories leading to this postulate were: Ortega & Gasset's **limitedness**; Heidegger's ***Ge-stell***, and **cultivate**; and Mayz Vallenilla's **domain**.

This postulate seeks to raise awareness that it is sensible to set limits to the power of technique. It also responds to the conviction that every technical action of man, as it is a free choice, entails consequences and ethical responsibilities. Not everything that is technically possible is a necessity. It is desirable to think carefully about what should or should not be created, according to real needs.

Consider the use of certain innovative technological resources in education. The advisable thing would be that people in charge of decision-making regarding technology to be used have enough time to assess the options, to plan, execute and then evaluate the performance and the lessons learned. But the whirlwind of available resources, its outdated and immediate replaced by other more advanced versions, plays against deliberation and option assessment, as well as on the evaluation of experiences carried out. Decision-making cannot be the result of mere technological trends nor be based on the pressure of regional or worldwide academic environments.

b) Being prevails above possessing and being useful: the German Episcopal Conference issued a statement on the environment and energy supply entitled *Zukunft der Schöpfung – Zukunft der Menschheit* [The Future of Creation - The Future of Mankind] in 1980, which addressed issues related to technique as human activity, energy and the environment. It declares that sometimes we run the risk of valuing people, and everything else, only for their usefulness. It goes on to state "the primacy of being over

having regarding people, and the primacy of being over being useful regarding non-human creation" (1980, p. 9) (own translation).

Hence, the idea of this second postulate: to have a proper relationship with technique, it is necessary to keep in mind the priority of being over having and being over being useful. There are several categories on which this proposal is based: Ortega speaks of **Nature**; Mayz Vallenilla of **Instrumentalization**, and of **Human Dignity**; and Heidegger highlights **Concealment**.

An ethics of the technique must lead to recognize that a person's being, and that of all entities, is above their possessions, their function or utility in the plot of technical relations of the social fabric. Human dignity is the highest value, which should be cultivated and defended, rather than valuing the technical objects possessed. The rest of nature's entities also already have an intrinsic value given their existence, even if they do not provide people with immediate technical service.

Regarding educational technology, we must renew people's preeminence over things. For instance, often, in technology-mediated learning environments, it is hard to communicate our emotions, our feelings, our body language, which are fundamental in human relationships, in communication, and of course, in teaching and learning. An alternative to mitigate these deficiencies is the use of videoconferences in which part of these fundamental human experiences can be captured. The solution is to try to find innovative alternatives in technology that allow us to express ourselves in the most transparent way possible so that our interlocutors can perceive us as we are.

c) Promoting a culture of austerity, not of consumption or discard: Adela Cortina (2002) states that "equal access to consumer goods is a pending ethical task, which cannot consist in universalizing the «American dream», because the people nor the earth would resist it" (p. 231) (own translation). For consumption to be truly human, it must be autonomous, fair and granting. Autonomous: that is, without coercion of advertising. Fair: that our consumption pattern be universalizable to all without depleting the plan-

et's capacity. Granting: that consumption leads us to achieve our goals of happiness.

The third postulate proposed is linked to Cortina's: a culture of austerity is necessary in the use of technology, which may surpass the drives of consumption and shedding. Related categories are Heidegger's **Releasement**; Ortega & Gasset's **absorption** and **alteration or animality**; and Mayz Vallenilla's **Understanding**.

The postulate suggests that austerity, a control of the culture of consumption and discard, is necessary in our relationship with technique. Current technological society is highly consumer of itself. Being at the forefront of technology means being willing to continually buy, use and discard. The technological world forces us to shed obsolete software, old cell phones, previous generation computers or tablets, lower resolution TVs, not only because equipments have very short lives, but also because even if we take care of them, and these continue functioning, they are no longer compatible with the new features of the global connection system.

Training and education in virtues and values that fosters a culture of austerity in the face of technological advances is therefore necessary. This new attitude can even be fostered from the technology-mediated learning spaces: an attitude of releasement towards new artifacts and overwhelming advertising. You don't have to buy all the new equipment available. This could be through a course in technology, ethics or social issues arising from technology use. This type of course could warn of what Pope Francis calls «rapidation» (2015, p. 17), referring to the continuous and vertiginous changes to which technological and consumer society lead us. Another fundamental aspect derived from this postulate is the need to train for freedom. School and the universities have a duty to train citizens, that is, free people.

d) Technique is at the service of living: "God blessed them, saying to them, «Be fruitful, multiply, fill the earth and subdue it. Be masters of the fish of the sea, the birds of heaven and all the living creatures that move on earth»" (Gen 1:28). "Yahweh God took the man and settled him in the Garden of Eden to cultivate and take care of it" (Gen 2:15). The book of Genesis highlights

> the command of God to man to settle on earth, to fill it as a species, but at the same time, to cultivate it and, above all, take care of it. In short, God calls man to inhabit the Earth, establish our abode in it, our home. When we live in a place, we don't destroy it, we embellish it, to make it a pleasant place.

The fourth postulate arises from this conviction: the technique must lead us to human habitation. If the opposite occurs, then it fails to fulfill her primary function. The categories that inspire this postulate are Ortega & Gasset's **Reform of nature**, **supernatural**, **comfort** and **emptiness**; Heidegger's **building**, **inhabiting**, "**Being-in-the-world**", and **uprooting**; and Mayz Vallenilla's **anthropocentrism**, **geocentrism**, and **trans-reality**.

This postulate invites us to become aware that the purpose of the technique is to inhabit, that is, to produce a habitable place for man, in the midst of a nature that offers facilities and difficulties. The technique provides us with the means to build our dwelling, our home, our shelter. But the search to inhabit through technification has led us to the opposite: to uprooting, to the loss of our roots, to disconnection with the earth, to the gradual destruction of our dwelling: the world. Technology may be emptying our meaning, emptying our being.

It is curious that etymologically the word "ethical" comes from the Greek expression ηθος [ethos], which means character or mode of being, but also dwelling on where it is inhabited. Thus, living is linked to ethics, and García (2015) highlights the importance of this relationship. For a healthy living we require a solid formation in virtues and values on the adequate use of technology, a continued reflection on our action that allows us to understand that our dwelling cannot be destroyed, on the contrary, it need to be maintained, cultivated, and protected.

In this same sense, the increasing technification of education has been contributing to the construction of a parallel world within the human realm: virtual reality, which would be the new artificial environment generated by computers, and in which human beings increasingly enjoy being immersed in. A critical ethic from education should aim to generate spaces for discussion in which this fact is reflected. In many ways, the virtual reality generated by technology is replacing the real world of traditional in-

teractions between human beings and their environment. Are we prepared for that? Do we have control over the consequences of this new reality, of this trans-reality? Does this trans-reality really lead us to human habitation, or does it uproot us?

e) There are fruitful relationships between art, poetry and technique:

> "Man in vain attempts to bring the globe in order
> through his plans whenever he is not in harmony
> with the message of the Fieldpath.
> The danger threatens that men of today
> remain hard of hearing to its language.
> They have ears only for the noise of the media,
> which they take to be almost the voice of God.
> So man becomes fragmented and pathless".
> (Heidegger, 2003. p. 37)

This extract from a poem by Heidegger in *The Fieldpath* (2003) refers to a path that the philosopher often traveled, which goes into the countryside of Freiburg, and then turns towards the beautiful forest of the Black Forest. Along the way, the centuries of human action are represented in harmony and mutual belonging to nature, but they come to be interrupted by a modern technical action that advances the sweeping of the natural world.

The poem and its content set the ground to raise the fifth postulate: poetry, art and technique must be articulated for mankind and the world to survive. The categories that have served as foundations are Ortega & Gasset's **Chance**, **Ignorance** and **Limitedless**; and Heidegger's **Truth** and **Disregard**, **Think**, **Art** and **Poetry**.

Ever since the Greeks, poetry, art and technique have been united through craftsmen who were people with artistic-technical skills and abilities product of their own manual experience. This link reaches its peak in the Renaissance. Leonardo Da Vinci is a clear example of a craftsman who knew how to harmoniously combine science, technique and art. According

to Tatarkiewicz (1980) poetry, technique and art take separate paths during the Renaissance with the flowering of science.

Poetry as a literary genre manifests the beauty of the entity through words. Its motivation is basically contemplative or descriptive about our surroundings, or communicative of our feelings. The purpose of art is also contemplative of the entity, of communication of our experiences through plastic, linguistic, sound, bodily resources, etc. The purpose of the technique is to transform reality for utilitarian reasons and is precisely scarce from a contemplative or communicational outlook regarding our more human dimensions. This is where poetry and art can enrich the technical work.

An interesting step in this path is the trend towards transdisciplinarity, which will allow educational institutions to prepare students of different levels, especially for an integral professional level, and not only in technical-specialized training. It would be interesting to offer all students one or several courses regarding the history art, poetry and technique, and the implications they could have on humanity were they to come back together in the construction of our future history.

g) An increasingly humane and comprehensive education is urgent:

> Understanding cannot be digitalized. Teaching the basics of mathematics or some other discipline is one thing, educating for human understanding is another. There we touch on the truly spiritual mission of education: teaching understanding between people as condition and protection of humanity's moral and intellectual solidarity. (Morin, 1999, p. 49)

Morin emphasized, among other things, that the primary mission of education is understanding between people. And this is truly pressing when he is convinced that, in the face of multidimensional and complex phenomena and events, we need a way of thinking capable of interconnecting different dimensions of the real. And where the ethical or moral dimension is urgent and fundamental.

This conviction has been the motivation for the sixth postulate of this thesis: Given the multiple facets that make up the real world, we need to overcome the technical vision and open ourselves to a more complex thought. The categories derived from the texts are: Ortega & Gasset's **science** and **method**, **specialization**, **claim of antonomasia**, **relativity**, **panoramic and synthetic education**; Heidegger's **provocation**; and Mayz Vallenilla's **homogenization**, **inter and transdisciplinarity**, and **general gumanistic studies**.

One of the commonplace discussions in the studies texts regards the danger of modern technique as mentality that transmitted to us: it assumes that everything is ours, that it belongs to us and that it is at our disposal. A critical and conscious ethical view should lead us to the awareness that reality goes far beyond human interests, and that entities' existence does not have to be absolutely at the service of man's needs. This means understanding the intrinsic complexity of reality, and realizing that to know it requires a holistic, and not just a technical, perspective. It means realizing that entities are not exclusively at our disposal.

From the field of education, and in order to achieve a more holistic view, universities of technical and scientific tradition worldwide, have begun to include in their curricula compulsory humanistic subjects such as politics, philosophy, literature, art, poetry, religion, personal development or inner experience. Coupled with a greater interrelation or interdependence between the scientific-technical matters, this may lead us in the right direction, yet we still have much to do.

h) Technique must lead the way to transcendence:

> It is absurd to think that Joseph was not a good craftsman, reputed both for his skill and for his honesty and righteousness. It was known in Nazareth, and undoubtedly throughout the region, that when addressing him, one was sure to pay a fair price and receive a work well done (Grasnier, 1980, p. 39) (own translation).

Such are the thoughts expressed in the book "Joseph the Silent". Joseph of Nazareth, husband of Mary and putative father of Jesus, knew how to combine his daily work of τεχτων [tekton] (translated as craftsman, builder,

technician, and sometimes as carpenter) with a life virtuous, of intense spirituality. He is described as someone who deserved the privilege of being chosen as the custodian of the Redeemer. Precisely, in that spirituality, in union with God, is the foundation of decent work in the service of the people around you.

This idea has been the motivation for the seventh and final postulate: it is necessary to be open to spirituality and transcendence in technical tasks. Some categories found on the matter are: Ortega & Gasset's **absorption**, **wholeness perspective**, and **techniques of the soul**; and Mayz Vallenilla's **universal political humanism** and **human dignity**.

This ethical postulate invites us to overcome our technical view of the world and open ourselves to other fundamental dimensions of the human being, such as the spiritual gaze towards the transcendent. Undoubtedly, the technical vision is pragmatic, it is immanent: it is about solving practical problems of everyday life. But it is clear that man has a strong inclination towards metaphysics, that is, the approach and search for answers to radical questions and meaning. If the technique distracts us from asking ourselves these fundamental questions, then it is stunting our radical human being.

However, if with technological assistance, we can pose these and other questions of meaning in the educational field, we can create learning environments where we can speak freely about the spiritual, about the values and virtues that define a holistic human being. Then, the same technology could be freeing us from the purely technical-utilitarian use and opening us to transcendence. Obviously, for many human cultures, the answer of who God is, what reality is, and who we are, is linked to how we should behave and why.

Finally, the transcendent gaze also drives us to openness towards mystery. The technical mentality tries to know everything, explore everything and exploit everything. But it turns out that there is a certain intrinsic unknowableness in reality. There are parts of it that remain veiled to us, and we must learn to live with that. Therefore, this postulate invites us to remain calm in the face of mystery, the supernatural, or the divine. And to

know that sometimes it is enough to face incomprehensible life experiences, where understanding fails to penetrate, with an attitude of admiration and Love, the greatest of virtues.

Final discussion

Regarding hermeneutics within qualitative research in education, the unique, essential, or universal repetitive truths are not relevant. Instead, it aims to know each of the everyday, existential, factual views of each researcher about the universe that gives life to the multicolored human knowledge world. It would be expected that any other researcher-interpreter of the same texts used in this research would develop different categories to those proposed. Likewise, these postulates should also have different meanings for other readers-interpreters of the same books. The seven constructed postulates do not entirely exhaust the richness of the interpreted texts.

As the ethical postulates derived have represented a call for personal transformation as a citizen, a teacher, a student of philosophy, or a human being, it would be satisfying to know if these considerations have also aroused the concern on ethics regarding technology in any reader. Rather than offering answers, the exercise of philosophy lies in posing questions that motivate each person to seek alternatives with conscientiousness. This is also part of the essence of Constructivism in education: more than providing students with the answers, they must be motivated by the teacher to ask questions and look for their answers, becoming the architects of their learning.

Regarding the ethical view that is required in educational technology, it is inevitable to address another side of the technical reality in the Venezuelan context. It turns out that this technique that has helped man build civilization and humanity has been slowly disappearing from Venezuelans' daily lives. Especially in educational institutions, there is a lack of Internet, electricity, telephone network in computers; even paper, books, or the minimum elements for learning are lacking. We are attending an intentional involution of technology in education, and with that, we are pushed to a return to animality, which we had overcome given the comfort technology had given us. People without education are more compliant and malleable to the intentions of the dictatorship.

We hope Venezuelans will soon find the way to freedom, common sense, and progress. If the desired changes occur and the reconstruction of the country begins, we bet on a process of innovation and technological renewal with a more humane and ethical sense. Moreover, we hope schools can lead this citizen-training program that understands the need for ethics in technology use.

References

Bailly, A. (1993). *Dictionnaire grec – français*, París, Francia: Hachette.

Bergson, H. (1959). *L'évolution créatrice*. París, Francia: Les presses universitaires de France.

Burgos, C., Rodríguez, S., Piñeros, I., & Moreno C. (2018). Sobre el uso de la técnica y tecnología en educación. In: Morales, J. & Rodríguez, S. (eds.) *Las TIC, la innovación en el aula y sus impactos en la educación superior.* (pp. 13 - 34). Bogotá: Universidad Sergio Arboleda/ASCOLDE.

Camps, V. (ed.) (2002). *Historia de la ética: 1. De los griegos al Renacimiento*. Vol. 1. Barcelona: Crítica / Filosofía.

Cortina, A. (2002). *Por una Ética del Consumo. La Ciudadanía del Consumidor en un Mundo Global*. Madrid: Taurus – Pensamiento.

Ferrater Mora, J. (2004). *Diccionario de Filosofía*. Barcelona: Ariel.

Francis (Pope), (2015). *Laudato Sí'*. Encyclical Letter. May 24, 2015.

Franklin, U. (1999). *The real world of technology*, Toronto, Canadá: Anansi.

Gadamer, H. – G. (2004). *True and Method*. (J. Weinsheimer & D. Marshall, Trad.). London – New York: Continuum Publishing Group.

García, S. (2015). *La relación entre el habitar-ethos y la ética. Antropología educativa*. I+D Revista de Investigaciones, 6(2), 6-18.

Gayol, Y. & Schied, F. (1997). *Cultural imperialism in the virtual classroom: Critical pedagogy in transnational distance education*. Retrieved from https://www.academia.edu/4512128/Cultural_Imperialism_in_the_Virtual_Classroom_Critical_Pedagogy_in_Transnational_Distance_Education [Consulta: 2019, agosto, 16].

German Episcopal Conference (1980). *Zukunft der Schöpfung – Zukunft der Menschheit. Erklärung der Deutschen Bischofskonferenz zu Fragen der Umwelt und der Energieversorgung*. Bonn: Herausgeber: Sekretariat der Deutschen Bischofskonferenz.

Grasnier, M. (1980) *Los Silencios de San José*. (J. E. Perruca, Trad.) Madrid: Palabra.

Grondin, J. (1999). *Introducción a la Hermenéutica Filosófica*. Barcelona, España: Herder.

Hallak, J. & Poisson M. (2007). *Corrupt schools, corrupt universities:What can be done?* Paris, Francia: International Institute for Educational Planning, UNESCO.

Heidegger, M. (1966). *Discourse on Thinking. A Translation of Gelassenheit*. (J. M. Anderson and E. H. Freund Trads.) New York: Harper & Row, Publichers.

Heidegger, M. (1977). *The Question Concerning Technology. And Other Essays*. (W. Lovitt Trad.) New York & London: Garland Publishing, INC.

Heidegger, M. (1981). "Only a God Can Save Us": The Spiegel Interview (1966). In: Sheehan, T. (ed.) (1981) *Heidegger: The Man and the Thinker*. (W. Richardson Trad.) New Brunswick: Transaction Publishers.

Heidegger, M. (1994a). *La pregunta por la técnica*, en: *Conferencias y Artículos*, (E. Barjau Trad.) Barcelona, España: Del Serbal.

Heidegger, M. (1994b) *Construir, Habitar, Pensar*, en: *Conferencias y Artículos*, (E. Barjau Trad.) Barcelona, España: Del Serbal.

Heidegger, M. (2001). *Being and Time,* (J. Macquarrie & E. Robinson, Trad.) Oxford: Blackwell Publishers Ltd.

Heidegger, M. (2003). *Camino de Campo*. (C. Rubíes Trad.) Barcelona: Herder.

Laudadío, J. (2015). Ser Profesor Universitario, desafío digno de ser emprendido. *Perspectiva Educacional, Formación de Profesores*, enero 2015 vol. 54 (1). Retrieved from http://www.perspectivaeducacional.cl/index.php/peducacional/article/viewFile/271/147

Martínez, M. (2004). *Ciencia y arte en la metodología cualitativa*. México D.F, México: Trillas.

Mayz Vallenilla, E. (1967). *La Universidad y su Teoría*. Caracas, Venezuela: Universidad Simón Bolívar.

Mayz Vallenilla, E. (1972). *La Universidad en el Mundo Tecnológico*. In: *El sueño del Futuro.* Caracas, Venezuela: Universidad Simón Bolívar.

Mayz Vallenilla, E. (1974). *Esbozos de una crítica de la razón técnica*. Caracas, Venezuela: Universidad Simón Bolívar.

Mayz Vallenilla, E. (1990). *Fundamentos de la meta-técnica*. Caracas, Venezuela: Monte Ávila Editores - Instituto de Estudios Avanzados.

Mitcham, C. (1989). *Martin Heidegger: La pregunta por la técnica*, en: ¿Qué es la Filosofía de la Tecnología?, Barcelona, España: Anthropos.

Morin, E. (1999). *Seven Complex Lessons in Education for the Future.* (N. Poller Trad.) UNESCO Paris: Publishing.

Ortega & Gasset, J. (1941). Men the Technician. In: *History as a System. And Other Essays Toward a Philosophy of History.* (H. Weyl Trad.) New York: W. W. Norton & Company INC, pp. 87 – 161.

Ortega & Gasset, J. (2000). *Introducción: La universidad y la Técnica*. En: *Meditación de la Técnica y otros ensayos de ciencia y filosofía*. Madrid, España: Revista de Occidente en Alianza Editorial.

Ortega & Gasset, J. (2006a). *Meditación de la Técnica*. En: *Obras Completas*, t. V, Madrid, España: Taurus–Santillana.

Ortega & Gasset, J. (2006b). *Ensimismamiento y Alteración*. En: *Obras Completas*, t. V, Madrid, España: Taurus–Santillana.

Pineda, E & Alvarado, E. de (2008). *Metodología de la Investigación*. Washington, D.C, Estados Unidos: Organización Panamericana de la Salud.

Piñero M. & Rivero M. (2012). *Investigación Cualitativa: Orientaciones Procedimentales*. Barquisimeto, Venezuela: UPEL – IPB.

Sandín, M. P. (2003). *Investigación Cualitativa en Educación. Fundamentos y Tradiciones*, Madrid, España: McGraw-Hill.

Sullivan, E. (1983). Computers, Culture, and Educational Futures: A Critical Appraisal, *Interchange*, 14(3) pp. 17 – 31.

Tatarkiewicz, W. (1980). *A History of Six Ideas. An Essay in Aestetics*. (C. Kasparek Trad.) Warszawa: Martinus Nijhoff.

The New Jerusalem Bible NJB (1985) New York: Darton, Longman and Todd and Les Editions du Cerf.

UNESCO (2013/4). *Teaching and Learning: Achieving quality for all.* EFA Global Monitoring Report, París: UNESCO.