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Artículos de investigación científica y tecnológica

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Uso de recursos educativos abiertos en matemáticas para la formación integral de estudiantes de grado séptimo de educación básica secundaria

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INTRODUCTION

The current knowledge society we live in unfolds in complex contexts that demand nurturing potentialities to assume important challenges in decision-making processes concerning fundamental matters such as choosing a profession without knowing about future jobs, creating an ethical and sustainable company, starting a family, studying and working in multicultural environments and making proper use of time. Challenges such as these have existed before but are now heightened due to uncertainties discussed in Morin's (1999) document *Seven complex lessons in education for the future.*

Traits of these complex contexts include developments such as information and communications technologies, which offer possibilities for innovation in many fields of social and educational life. In the latter, ICT may transform learning environments, yet its use must be planned and intentional and must review and analyze its effects on students' training processes. Technological innovation alone does not bring pedagogical improvement or desired training effects, which, according to Diaz-Barriga (2011), lead to a transformation of what is known and not just to repetition. The identification of these effects was the main objective of the research presented herein.

With this technological reality in mind, basic and secondary education have been fostering proposals to offer comprehensive education focused on developing comprehensive competences. The Ministry of National

Education (MEN, for its Spanish acronym) has published different documents and enacted provisions aimed at encouraging the educational sector to adopt technology as an adequate element for learning in core areas of basic and secondary education (MEN, 2008). Mathematics, one of the aforementioned areas, was chosen to be part of this research's methodology. A ponderation of the educational reality makes it necessary to admit that implementing technology in schools has been a slow enterprise. According to Gates (1995), that slowness could derive from an overall trend of conservatism or from lack of resources.

Diverse documents circulate in the educational sector illustrating the significance of using ICT in educational processes and that account for the benefits resulting from it (Lopez and Hederich, 2010). At the same time, verifying results' attainment (Lopez, 2019) is necessary. Identifying and analyzing evidence of students' experiences while engaged in comprehensive training activities aided by technological resources became a core aspect of this research

Evidence was gathered based on a development approach of comprehensive competences, without disregarding that the competence approach has been regarded as controversial (Diaz-Barriga, 2011). This controversy has been proactively considered to give the research an educational and humanized nature. In that regard, Tobon (2004) contributes the concept of competence-based training as an educational proposal oriented towards human comprehensive training, integrating theory and practice, improving coexistence, steering life projects and articulating educational system's levels. This author makes a significant contribution to the effort of humanizing the aforementioned approach because he suggests considering three dimensions of competences, as follows: affective and motivational, connected with attitudes and values; cognitive, pertaining factual knowledge, concepts and cognitive skills; and procedural, related to procedural abilities and techniques. Perrenoud (2009) analyzes potentialities and limitations of competence-based training and highlights the importance of an interdisciplinary management of knowledge.

The educational project of the institution in which the research took place follows a pedagogical training approach consistent with developing comprehensive competences across every curricular area. Locally, in mathematics, there is the availability of Open Educational Resources (OER), there is also the possibility to access organized repositories in other countries, tapping into the open educational movement. These conditions are of interest for the institution based on its pedagogical application, its effects on learning and as aid to solve difficulties that frequently arise in mathematics. This topic has been covered by Aragon, Castro, Gomez and Gonzalez (2009). Moreover, reports by the Organisation for Economic Co-operation and Development (OECD) concerning the 2012-2016 PISA program, reveal that Colombia is still one of the countries with the lowest average in mathematics, although with a mild improvement in 2015; the educational institution where the research takes place needs to look for strategies to attain better results.

The existence of technological resources that can be used in education, the purpose of comprehensive training in the selected institution, the shortcomings in learning mathematics and the need to evaluate the effects of using ICT through OER are aspects that justify this research. As per its scope, the mathematics area was selected due to the fact that a teacher had begun an experience using said materials.

From many studies that precede this research, the following can be selected: *Learning environments* (Jaramillo and Ruiz, 2010); *Implementation processes of OER and learning object* (Mortera, 2011). *Developing in individuals the capacity to undertake new things, be creative, discoverers and permanently learning as an objective of the 21 st century education* (Ramirez, Huerta and Florez, 2012). *Increased motivation in students caused by conducting authentic activities in a context close to the real one* (Naeemi, Zare, Hormozi, Shaqaqi and Kaveh, 2011). *Use of OER and learning objects to improve mathematical competences* (Pazos, Tenorio and Ramirez, 2015). *Competences for problem-solving in mathematics* (Aviles, Diaz, Esquivel and Hernandez, 2010). *Collaborative learning based on ICT* (Garcia-Varcarcel, Hernandez, Muñoz-Repiso, 2012).

THEORETICAL FRAMEWORK

In educational sectors of current changing and complex societies, there is increased awareness of the need to train people who know, value and nurture their capacities; for people to be creative, be willing to constantly learn and have the necessary skills and criteria to take advantage of technological resources in managing and solving issues and problems connected with work, life itself and the common good. Fulfilling expectations such as those comes with the necessary (albeit insufficient) condition of educational systems promoting student training as per current demands and possibilities.

In response to that reality, multiple offers to fully develop human potentialities (comprehensive education included) have been positioned in the school culture, driven by Gardner (1988) and his collaborators' advancements in cognitive science, especially in psychology. Additionally, permanent and global communication through ICT potentially affects the configuration of children, teens and adults' social identity. Also, communication media and social networks offer access to the most diverse knowledge. Such is the context of training focused on comprehensive competences development nowadays.

Competences and the Competence-Based Training Approach

In formal education, the term competence was coined by the area of language in 1960, from then on, theoretical constructions and models have been produced for its application and massively disseminated in educational policies throughout numerous countries. According to Lopez (2014), the term competence has two nuances deriving from Latin

etymology: one comes from the verb *cumpetere* as compete, meaning expertly knowing and having a know-how, and the other comes from *competitum* as competing, knowing how to be, overcoming and making an effort. Thus, competence is the sum of knowing, know-how and knowing how to do.

Opposing positions take place among educators in terms of the incorporation of the competence approach in education. Diaz-Barriga (2011) mentions that some consider it to be the opposite of an individual's comprehensive training ideal, and mostly oriented towards the working world and competitiveness. Tobon (2004) suggests that said these positions have generated discussions in the last decades and hindered the implementation of this approach in formal education curriculums.

Comprehensive Competences and Comprehensive Training

The matter of comprehensive competences is extensive, its conceptualization can be done from several perspectives and using different names. However, analyzing the content of each, it is possible to find coincidences in the orientation towards students' comprehensive training. An example of said coincidence takes place with the proposals by Delors, Tobon, MEN and OECD.

For Tobon (2004), competence-based training is an educational proposal aimed at human comprehensive training, it allows merging theory and practice and improves coexistence, it also facilitates the articulation between the educational system's levels and steers a life project.

The proposal by Delors (1996), widely known in academic settings, arranges education's current missions in four pillars: learning to know, learning to do, learning to live together, and learning to be. These four pillars make it possible to build comprehensive training for children and teens.

For the author, learning to know implies learning to learn, exercising memory and thought and acquiring the bases to further learn. Learning to do is connected with learning to know and entails capacity to integrate theory and practice to establish stable and efficient relationships between people and deal with uncertainty. Learning to live together manifests in the capacity to participate in common projects, and in applying methods to avoid or solve conflict. The fourth pillar, learning to be, refers to knowledge of the self and of others and the openness towards others; this implies a full deployment of talents, autonomous actions, memory cultivation, reasoning, aesthetic sense, physical capacities and communication aptitudes.

In syntheses, it can be stated that Delors believes comprehensive competences interweave knowledge, capacities, attitudes, values and skills as qualities to be developed in a person when he/she is regarded and trained as a whole. The four pillars constitute what is known as comprehensive competence.

In the suggestions by OECD (2005) it is possible to infer that for this organization, a competent person acts effectively because he/she integrates and mobilizes practical skills, knowledge, motivations, values, feelings and attitudes. Adding that a wide range of these competences is key for humans to suitably face current challenges. It organizes them in the following groups: interactive use of tools, interaction between heterogeneous groups and autonomous actions. It lists three dimensions that need to be taken into account while developing these competences: information, communication and ethical and social impact. Each dimension is assigned with content. The dimension of information includes access, evaluation and organization of information, research and problem solving. The dimension of communication highlights the capacity to communicate, exchange, criticize, present information and use ICT applications. The dimension of ethical and social impact breaks down into acting with positive social effect, applying criteria to use ICT responsibly, having critical thinking and having the capacity to make decisions.

In Colombia, the Congress of the Republic and MEN have produced regulations and documents in which they set forth provisions and guidelines to develop competences, each has been assigned a name. In 1994, the Congress passed Law 115, also known as the General Law of Education; its Article 5 defines the purpose of Colombian education, and Article 92 outlines a profile of the citizen of this country. Both Articles recommend competences that, in general terms, match those proposed by Delors, OECD and other authors.

To conduct the implementation of Law 115, MEN has designed and delivered plenty of documents, namely: *Basic Standards for Language, Mathematics, Science and Citizenship Competences* (Document 3, 2006). *Guide No. 21: articulation of education with the productive world* (2005), and *Guide 30: being technologically competent* (2009).

The concept of competence in these three documents agrees with what has been previously introduced regarding the ideas by Delors and OECD. The report entitled *Educational Revolution 2002-2010, Actions and Lessons*, MEN (2010) clusters the following as comprehensive competences: basic (scientific, civic, communicative and mathematical), working and professional. This stance is also observed in MEN (2005).

MEN (2008) identifies some challenges that must be addressed in technology training: increasing motivation to stimulate scientific and technological curiosity; recognizing that technological knowledge contributes to solving problems and transforming the environment; critically pondering the connection between technology and society; facilitating experiences of activities related to technological knowledge and providing people with tools to actively engage in their settings.

Based on the aforementioned ideas, comprehensive competences are considered a set of knowledge, skills, attitudes and values acquired and nurtured by an individual, through which he/she deals with the demands of daily life.

Collaborative Learning

Human interaction is more and more valued in familial, school, business, sports and commercial contexts. In particular, it is intentionally valued in educational institutions where it is used as human integration strategy aimed at enhancing learning processes, contributing to mutual knowledge, facilitating problem solving, allowing the development of projects with common interests and encouraging permanent learning. Dialog among people and groups is useful to achieve collective changes in ways of thinking and to merge wills with the purpose of attaining agreed goals.

When dealing with the significance of interaction in learning processes, learning theories confirm that in situations of collaboration, members of a group exchange efforts so that achieving a common goal generates benefits for each (Garcia-Valcarcel, Hernandez and Muñoz-Repiso. 2012).

Based on the research, Fernandez-Cardenas (2011) admits that education's quality depends on processes taking place in the classroom and advocates for a socio-historical perspective to define relevant aspects in detail, emphasizing on elements such as socialization, mediation, negotiation of meaning and community. All of these aspects are pertinent within collaborative learning.

It can be said that collaborative learning is a human interaction strategy. Through dialog, groups of people may sustain change at collective levels in terms of the way of thinking, as well as joining efforts to attain common goals aimed at maximizing learning.

Mathematical Competences

Contributions of mathematical education to comprehensive training, and thus to the development of comprehensive competences, are a topic of debate in academic, social and familial circles. MEN's *Document N° 3* (2006) takes part in the discussion, stating:

> Mathematical education must respond to new global and national demands, e.g., demands of education for all, consideration of diversity and interculturality, and training citizens with necessary competences to exercise their democratic rights and duties (p. 46)

In the same document, MEN supports its claim with arguments connected with the role of mathematics in plastic arts, engineering, economy and trade. It adds the contributions made by this discipline to training in logical thinking and development of science and technology.

The document by MEN goes deeper into the analysis of some aspects in mathematical education; it bases the idea that learning processes in mathematics are not isolated but imply components of social and affective nature, connected with specific learning environments, thus, associating mathematics with education's cultural purpose. It emphasizes the importance of classwork to create a learning community with

teachers and students' interaction to favor critical thinking, initiative and knowledge validation.

Mathematical competences have also been conceptualized by the OECD. The report of the 2006 Pisa program considers them as the type of capacities acquired by people which allow them to reason, comprehend, investigate, argue and communicate on the part mathematics play in their individual and collective lives, facilitating the application of mathematical reasoning in problem solving (2013).

This work inquired into the competences of recovery of information, recognition of simple rules and problem solving.

OPEN EDUCATIONAL RESOURCES (OER)

OER are free, web-based and digital resources for teachers, students and researchers. These encompass documents of text, audio, video, educational games, websites, complete courses, course materials and software tools that enable access to knowledge. These are developed using ICT and are allowed for non-commercial purposes (Mortera, 2011). OER are easy to locate, reusable, can be adapted to different computers, function properly and benefit from the existence of repositories. The Open Educational Movement (*Movimiento Educativo Abierto*) seeks to put knowledge within reach of a larger number of people to close the gap between countries using resources of quality (Mortera, 2011).

Research focused on the development of comprehensive competences with typical activities of the selected area and aided by the following OER: GeoGebra, probability, Pythagoras's theorem, descriptive statistics graphic plotters, and the Edmodo social platform.

Considering the significance of children and teens' comprehensive development, of the possibilities that technological resources have to offer education and the convenience of using them in mathematics to improve learning, the following research question came up: What is the effect of using ICT-mediated OER in mathematics for comprehensive training of seventh grade students of basic secondary education?

This question was formulated with the following subordinate questions: What is the acceptance level reported by seventh grade students of basic secondary education concerning the use of ICT in the development of comprehensive competences? What benefits are reported by seventh grade students of basic secondary education to have been attained with the use of OER in collaborative learning mathematics activities? What are the effects on learning acknowledged by seventh grade students of basic secondary education in terms of using OER in mathematics?

The foregoing questions were formulated to help fulfill the following objectives:

General Objective. To identify the effect of the use of ICT-mediated OER in mathematics for comprehensive training of seventh grade students of basic secondary education.

Specific Objectives. To explicit the level of acceptance manifested by seventh grade students of basic secondary education regarding the use of ICT in technology-mediated environments and oriented towards comprehensive training in permanent learning, management of information and life situations, and competences for life and society.

To identify benefits reported by seventh grade students of basic secondary education to have been attained with the use of OER in collaborative learning activities using ICT to develop oral communicative skills, interaction with others, valuation of tutoring, mutual help.

To infer characteristics of ICT-mediated OER in mathematics learning oriented towards the recovery of information, comprehension and learning of concepts, use of algorithms and motivation of pedagogical usage of technology, acknowledged as having been experienced with its interactive use by seventh grade students of basic secondary education.

To find answers to these answers, the research was conducted adopting a mixed approach with quantitative and qualitative components.

METHOD AND INSTRUMENTS

Among the various approaches that could have been adopted by this research, the mixed approach proposed by Hernandez Sampieri (cited by Hernandez, Fernandez and Baptista, 2010) was selected; it seeks the strengths of both quantitative and qualitative investigation, combining them and trying to decrease its weaknesses. Thus, a quantitative and a qualitative component take place in one same study; objectives are reached through systematic, rigorous and critical data collection processes for each component and through results' analysis and integration, in order to make inferences that help understand better the fact, phenomenon or situation being studied.

Design of the Quantitative Component

The research's quantitative component was a cross-sectional, non-experimental and descriptive design. Since it was non-experimental, the research was conducted without deliberate manipulation of variables, basically, the idea was to observe and describe facts or phenomenon as they take place in a specific context and to collect information on the variables for posterior analysis (Dzul-Escamilla, 2013). Due to the fact that it is cross-sectional, quantitative data was collected at a single moment, since it was important to describe the variables of interest and analyze the effect of using OER in the development of the competences being studied at a given moment. For this component, a Likert scale and a questionnaire were applied.

Design of the Qualitative Component

The design of the qualitative component included the preparation of techniques that allowed information collection along with participating students and with semi-structured interviews and a moderate-participation class observation guide. The attempt was to interpret the meaning of students' experiences about the use of OER in mathematics to complement the information of its impact on comprehensive competences development.

The categories in this component were: OER-mediated learning with indicators of usefulness, self-regulated performance and motivation; mathematical competences with indicators of recovery of information, recognition of simple rules, logical reasoning; and collaborative learning with indicators of interaction, feedback, common good, comradeship.

Prioritization of one of the Components

The quantitative component was prioritized due to the fact that it allowed an overview of the researched phenomenon, some competences that were the object of the study were delved into using the qualitative approach. Overall, it was a concurrent design (Pereira, 2011).

Procedure

The research focused on the ethical principles introduced by Valenzuela and Flores (2012) in terms of purpose, length, procedures to follow, people to contact and informed consent. Mathematics classes in the seventh grade undertook GeoGebra sessions and teachers conducted other contextualized practices with participants in order to interact with the selected OER. Questionnaires on comprehensive and technological competences and the collaborative learning survey were applied to the sample of 76 students. Three observations were conducted in class. Subsequently, other sessions with seven students of the intentional sample took place in order to apply semi-structured interviews.

Quantitative data obtained with the Likert scale and the survey was collected and processed using the SPSS software. Answers to the open questions in the collaborative learning survey were typed in Excel charts to decrease data following affinity criteria. Interviews were transcribed and the observation guide was used for its respective analysis. Concerning the internal and external validity, the causes for invalidation explained by Valenzuela and Flores (2012) were foreseen.

The qualitative component included 21 interviews with seven students, three interviews each. Each interview had one of the following as OER topics: Introduction to the concept of probability; practical and interactive probability exercises; Pythagoras theorem; basic illustrative explanations; Pythagoras theorem; illustrative exercises; Pythagoras theorem; interactive practical exercises and GeoGebra.

The study's reliability was defined with instruments measuring the object of the study with certainty; instruments with permission of usage that were previously validated by the authors were used. Some adaptations were made according to the context.

Instruments Used

Four instruments were used to collect information, all of which were duly validated by prior studies. Authors agreed to the corresponding authorizations. Three of the four instruments required minimum adaptations concerning the discipline selected by the study and the students age. The instruments were:

Comprehensive and technological competences. This instrument by Suarez, Rodriguez and Rodriguez (2012) is structured as follows: the first part inquiries into the use of technology, the second part includes a questionnaire with four sections on comprehensive competences and was done using the Likert scale. These sections refer to competences that accomplish permanent learning, managing information, managing life situations, and competences for coexistence and life in society. This instrument was applied to collect information about students' opinion on the implementation of OER in a technology-mediated learning environment.

Survey on collaborative learning. This questionnaire combines closed and open questions, it is by Martinez, Catala and Diaz (2013).

Semi-structured interview on OER. Created by Asprilla (2012) this is a guide for an open question interview.

Class observation guide. Observation was conducted under the modality of moderate participation, described by Valenzuela and Flores (2012). The model by Alvarado (2012) was used as guide.

In the non-experimental quantitative, descriptive and cross-sectional component, two questionnaires were applied following Valenzuela and Flores (2012), they state that in the descriptive and cross-sectional design, observations were made in a single moment in time and variables are individually quantified without describing connections between them.

POPULATION AND SAMPLE

The population of interest for this study was made up by 96 female students in the seventh grade at an official educational institution, who have previously used the free GeoGebra software in a class that integrates mathematics and ICT. Students continued using this software in geometry and statistics and other OER incorporated by teachers into class practice, additionally, they began using the Edmodo platform.

As per Hernandez, Fernandez and Baptista (2010), a probabilistic sample of 76 students was selected for the quantitative component (this size was suggested by the Stats 2.0 software) and it had 5% of error and 95% of reliability . The selection of students took place in the classrooms, using a tombola in which each student had the same likelihood to be selected. Interviews had an intentional sample of seven students; students with different performance levels were included.

RESULTS

Because the research focus was mixed, results obtained for both the quantitative and qualitative components are presented. The first part of the results shows a synthesis of the information obtained by processing students' answers to the instrument of Suarez et al. (2012) regarding the use of the technologies.The other findings are organized as per the study's objectives and the closure includes the answer to the formulated research question.

Use of Technology

The 76 students in the sample were questioned on availability and use of technologies, a decisive aspect for the development of technological competences. Findings show that 95% of the participants have a computer at home, some have one and others have two. 96% has Internet at home and over half of them have a wireless connection. Only 4% does not have Internet at home but uses connections of friends and family members. The daily use of Internet to study their subjects ranges between less than an hour (18.4%) and over two (17.1%). It seems, although students who filled in the instrument have widespread access to this technological aid, some still need more time to take advantage of it, considering that most have a computer at home.

Results of the First Objective Corresponding to the Quantitative Element

The objective was: To explicit the level of acceptance manifested by seventh grade students of basic secondary education regarding the use of ICT in technology-mediated environments and oriented towards comprehensive training in permanent learning, management of information and life situations, and competences for coexistence and life in society.

The inquiry of these four comprehensive competences was conducted applying the aforementioned instrument by Suarez et al. (2012). It disaggregates each comprehensive competence in a group of competences to be valuated using the Likert scale. The answer options and its numerical valuation are: Strongly agree 5. Agree 4. Neither agree nor disagree 3. Disagree 2. And Strongly disagree 1. Tables 1 and 2 illustrate the overall result.

Competence	Competence	N	Range	Min.	Max.	Mean	Deviation	Skewness		Place according to the mean
								Statistic	Error dev.	
Permanent learning	4. Problem solving	76	4	1	5	3.96	0.871	-0.793	0.276	12
	5. Logical reasoning and communication	76	4	1	5	3.96	0.916	-0.991	0.276	13
	6. Starting with technology and continuing autonomously	76	4	1	5	4.16	0.88	-0.92	0.276	8
	7. Admitting diverse answers and becoming motivated to look for different approaches	76	4	1	5	3.87	0.854	-0.929	0.276	16
Information management	8. Learning, assuming and directing their learning	76	4	1	5	4.24	0.892	-1.068	0.276	3
	9. Search and identification	76	4	1	5	4.28	0.842	-1.254	0.276	2
	10. Evaluation, selection and systematization	76	4	1	5	3.93	0.984	-0.985	0.276	14
	11. Analyzing, synthesizing, using, sharing	76	4	1	5	4.3	0.766	-1.311	0.276	1
	12.Processing and communication	76	4	1	5	4.12	0.993	-1.167	0.276	9

Table 1

Result of the Likert Scale for comprehensive competences – Constant learning and information management.

Source: compiled by the authors

Competence	Competence	N	Range	Min.	Max.	Mean	Deviation	Skewness		Place according to the mean
								Statistic	Error dev.	
Management of life situations	13. Learn and work alone	76	4	1	5	4.05	0.847	-1.184	0.276	10
	14. Learn and work as a team	76	3	2	5	4.18	0.86	-0.886	0.276	7
	15. Facing conflict positively	76	4	1	5	3.51	1.064	-0.41	0.276	22
	16. Negotiation and problem solving	75	4	1	5	3.65	1.084	-0.571	0.277	21
	17. Setting objectives concerning a project	75	2	3	5	4.2	0.805	-0.383	0.277	6
	18. Problem-solving vision	76	3	2	5	4	0.849	-0.403	0.276	11
	19. Coming up with and executing new ideas	76	4	1	5	4.21	0.884	-1.144	0.276	5
	20. Managing time effectively	76	4	1	5	3.78	0.974	-0.775	0.276	20
Coexistence and life in society	21. Deciding and acting with critical judgement concerning values	76	3	2	5	3.79	0.805	-0.225	0.276	19
	22. Considering social implications	76	3	2	5	4.22	0.793	-0.755	0.276	4
	23. Participating in the development of the locality	76	4	1	5	3.93	0.854	-0.796	0.276	15
	24. Acting respectfully towards social and cultural diversity	74	3	2	5	3.84	0.777	-0.248	0.279	17
	25. Acknowledging community's traditions	76	3	2	5	3.84	0.865	-0.066	0.276	18

Table 2

Result of the Likert Scale for comprehensive competences – Management of life situations and coexistence.

Source: compiled by the authors

These results provide a general outlook of what was reported by the respondents, the table shows average values for the 22 statements inquiring into comprehensive competences, ranging from 3.51 to 4.3, at a maximum of 5. Average standard deviation for the 22 statements was of 0.88 and the global skewness coefficient was of -0.785.

To analyze the results, the instrument's authors suggest four valuation scales that contain obtainable scores and its corresponding interpretation, as seen in Table 3. The sum of averages obtained for each set of competences make up each competence and provide it with global value.

Competences				
Permanent learning. Score	Information management. Score	Management of life situations. Score	Coexistence and life in society. Score	Interpretation
20-25	17-20	33-40	21-25	Very high
16-20	13-16	25-32	16-20	High
11-15	9-12	17-24	11-15	Medium
6-10	5-8	9-16	6-10	Low
0-5	0-4	0-8	0-5	Very low

Table 3

Valuation scales of results obtained in the questionnaire of comprehensive competences by Suarez et al. (2012).

Source: compiled by the authors based on what was indicated by the instrument's authors

Based on the data gathered, Table 4 contains the findings per competences for the four groups inquired into by the instrument.

Competence	*Sum of averages*	*Maximum possible score as per the number of statements*
Management of life situations	31	40
Coexistence and life in society	20	25
Permanent learning achievement	20	25
Information management	17	20

Table 4
Comprehensive and technological competences – Likert scale.
Source: compiled by the authors

Based on the aforementioned scales, the global result of the four competences is between Very high and High. Very high scored 17 points that account for 85% of the maximum possible in terms of management information. High scored 20 points that account for 80% in two competences: achievement of permanent knowledge and coexistence and life in society. And High scored 31 points that account for 77% in terms of managing life situations.

The highest reported average corresponds to the competences of analyzing, synthesizing, using and sharing information, which scored 4.3 points, the lowest scored 3.51 points and it corresponds to the competences to face conflict positively. Table 5 shows maximum and minimum obtained results. All averages range between 3.51 and 4.3.

Competence	Obtained average
Maximum:	
Analyzing, synthesizing, using and sharing information	4.3
Search and identification of information	4.28
Learning, assuming and directing self-learning throughout their lived	4.24
Considering the social implications of using technology	4.22
Coming up with and executing new ideas	4.21
Setting objectives to fulfill what has been foreseen in project planning	4.20
Minimum:	
Facing conflict positively	3.51
Negotiation and solution of conflicts	3.65
Managing time effectively	3.78
Deciding and acting with critical judgement concerning values and social and cultural rules	3.79

Table 5
Maximum and minimum per statement – Questionnaire of comprehensive and technological competences – Likert scale.
Source: compiled by the authors

These same results, regarded from a different criteria of presentation such as distribution of students' frequencies, considering the ranges established by Suarez et al. (2012) for each competence, showed that most students placed in the High and Very high scale, as seen in Figure 1 and in Table 6.

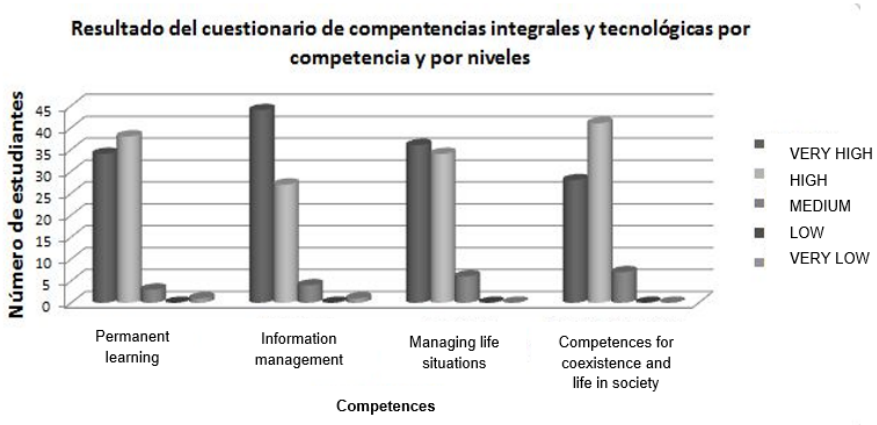

Figure 1
Distribution of results' frequencies obtained with the Likert scale.
Source: compiled by the authors

Competences	Level of accomplishment									
	Very high		High		Medium		Low		Very low	
	n	%	n	%	n	%	n	%	n	%
Competences to achieve permanent learning	34	45	38	50	3	4	0	0	1	1
Competences to manage information	44	58	27	36	4	5	0	0	1	1
Competences to manage life situations	36	47	34	45	6	8	0	0	0	0
Competences to coexist and life in society	28	37	41	54	7	9	0	0	0	0

Table 6

Distribution of results' frequencies obtained through the Likert scale.

Source: compiled by the authors

Results allow to see that over 90% of the students are in the first two levels of accomplishment of the competence. This means that students are receiving the discipline's knowledge from subjects incorporating ICT and they are also developing their capacity to apply self-regulation to learning in order to assume and direct their own learning throughout life. Their training in autonomy and openness towards knowledge are also being boosted. Regarding competences to handle information, students consider having good skills and dexterities to search for, handle and communicate information. As for the latter, it can be said that collaborative work conducted with peers entices students to search for and select resources that are then shared in presentations in the Edmodo platform.

The reliability of this first part of the study was calculated with Cronbach's alpha using the SPSS software, results were as follows: 0.895, considering the 22 statements of the Likert scale. For this same index, the results of each group of variables are observed in Table 7:

Competences	Number of items	Cronbach's alpha
Permanent learning	5	0.82
Information management	4	0.78
Managing life situations	8	0.713
Coexistence and life in society	5	0.693

Table 7

Cronbach's alpha coefficient obtained for the variables with the Likert scale.

Source: compiled by the authors

Results of the Second Objective Corresponding to the Qualitative Component

The objective was: to identify benefits reported by seventh grade students of basic secondary education to have been attained with the use of OER in collaborative learning activities using ICT to develop oral communicative skills, interaction with others, valuation of tutoring, mutual help.

The sample of 76 students took the instrument by Martinez et al. (2013), which was subject to minor adaptations. Some results are shown in Figures 2 and 3.

ANSWERS

*Figure*2.

Answer to the question about the connection between learning in teams and future job settings.

Source: compiled by the authors

Results obtained include: 68% consider that collaborative learning is appropriate to equally develop oral and written dexterities. Also, 85% considers tutoring to be largely important. The main positive aspects of learning in the group were: 53% attained better learning, 22% emphasized the significance of mutual help, while 25% referred to comradeship and opportunities to relate. Negative aspects include: 30% did not find a connection, 25% reported disorganization, while 23% discussions and disagreements, 11% of students did not work. 59% considers that collaborative learning has the same importance in primary as in secondary.

Students appreciate the importance of collaborative learning for the present and for the future, they mention that it enables sharing knowledge with peers, being more effective at learning and developing communicative oral and written skills. The foregoing is substantiated by Garcia-Varcarcel, Hernandez and Muñoz-Repiso (2012), who suggest acknowledging other current learning theories about interaction with others in learning. In general, there seems to be acceptance and awareness of different advantages offered by collaborative learning.

However, the information gathered on negative aspects of collaborative learning leads to the conclusion that work needs to be done to advance conflict-solving skills and encourage students towards responsible and equitable participation.

Interviewed students find collaborative learning to provide opportunities to interact with their classmates, improve their knowledge, contribute, ask the teacher and find solutions to difficulties that may arise, framed in a cordial and respectful environment. They are aware of the importance of the common good and of their contribution to fulfill it. However, a few say that not everyone contributes even though they could.

Following the notions of Garcia-Varcarcel et al. (2013) about collaborative learning being based on the constructivist theory giving a leading role to the student, and finding recurrent answers in the interviews, led the research to assign indicators of contact and feedback to the categories of interaction and common good, identifying benefits in

the learning process. It was also found that students were encouraged by being listened and listening and felt taken into account.

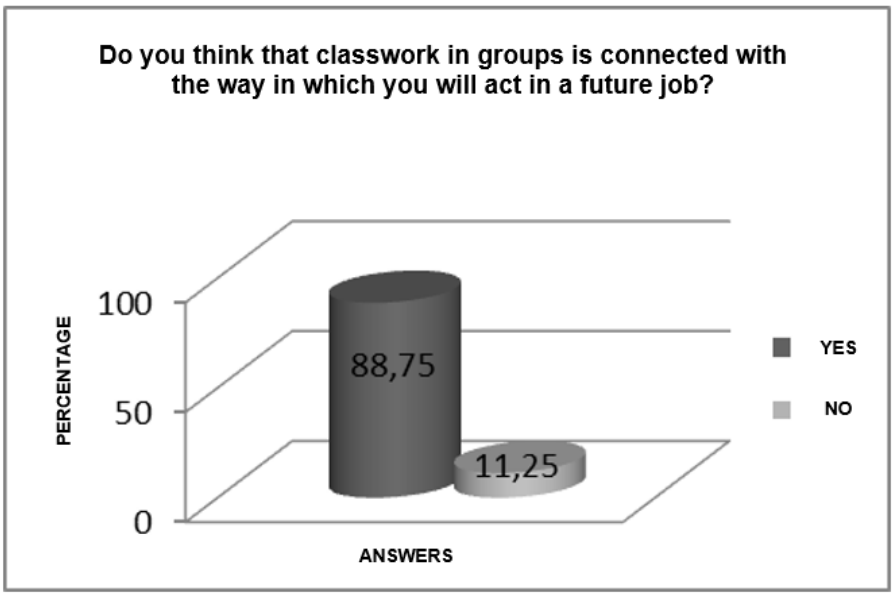

Figure 2.
Answer to the question about the connection between learning in teams and future job settings.
Source: compiled by the authors

Results of the Third Objective Corresponding to the Qualitative Component

The objective was: to infer characteristics of OER in mathematics learning oriented towards the recovery of information, comprehension and learning of concepts, use of algorithms and motivation of pedagogical usage of technology, acknowledged as having been experienced with its interactive use by seventh grade students of basic secondary education.

Interviewed students have found motivating elements in OER, as they interact with the resource they learn or they have fun because it is ludic, it introduces content differently in a visually attractive way, and they can do the exercises. OER give them control, e.g., they can rewind videos in case some parts are not well understood. It allows them to explore different levels of difficulty. These all account for usefulness, motivation and self-regulation.

Nevertheless, a few students had the need for more specific support throughout the process, it was found that in some cases, students fail to attain the proposed goal of the activity or do the exercises yet fail to understand them.

DISCUSSION AND RECOMMENDATIONS

Findings in terms of motivation, self-regulation and usefulness are supported by authors such as Mortera (2011) and Pazos et al. (2015). Concerning the relief students feel by having control of the video and replaying it to understand better, Perrenud (2009) suggests

that educational institutions have restricted themselves to providing knowledge to a limited percentage of students, consequently, OER properly incorporated to the curriculum is an alternative to bridging that gap. Usefulness of OER is recognized by students and it has been the subject of many studies and has been documented in articles such as that by Ramirez (2012).

Moreover, students reported in interviews that using OER helps them understand several topics and recover information on the concepts or its fundamentals. They can set their own learning pace and open their mind and ponder different alternatives to reach a solution. OER used enabled them to conduct interactive exercises, some with complementary response and information, to act as feedback and reflection of student-centered learning.

Referring to education supported by technological resources, Aviles et al. (2010) explain that said technologies are true cognitive scenarios which significantly engage the student, making him/her the center of their own learning. They stress that reflection and inquiry are core components in this new process. Interviews show that students manifested interest and liking for learning, even if they did not understand initially, they managed to attain progress with practice and self-regulated study.

Rodriguez and Saldaña (2010) recommend that students apply logical mathematical thinking in daily life situations, but to do so, this type of learning must start in school. Motivating and engaging students into actively solving mathematical problems is a step towards this goal. Nevertheless, to achieve better results and combine different aspects that lead to comprehensive training (such as collaborative learning) require adequate teacher training.

Researching MEN (2006) recommendations on mathematical competence standards for the sixth and seventh grades allowed identifying the exercise of the following competences:

I predict and compare the results of applying rigid transformations (translation, rotation, reflection) on bidimensional shapes in mathematical situations (GeoGebra).

I speculate about the results of random experiments using basic notions of probability.

I solve problems in contexts of relative measurements and variations of measurements.

It can be said that the three specific objectives were accomplished, moreover, the study allowed to identify competences directly related to technology-mediated learning environments, collaborative learning and mathematical competences.

As per the foregoing results, its validation using triangulation and subsequent analysis evinced that most students develop the competence of technology appropriation, specifically: "I use information and communications technology to support my learning processes and personal activities (collect, select, organize and process information)" (MEN, 2008, p. 20).

Comparison between results of some sub-competences in the Likert scale and information gathered from the interviews:

It was observed that results concur and that both lead to the acknowledgement of the usefulness of ICT, OER in particular, its motivation, and usefulness for self-regulated learning. For instance, averages of 4.24/5 and 4.2/5 in sub-competences regarding assuming and leading self-learning throughout life, lead to this congruence.

Interviewed students see collaborative learning as an opportunity to interact with their classmates, improve knowledge, contribute, ask the teacher and seek solutions to arising difficulties, in most cases, within a cordial and respectful environment. They are aware of the significance of looking for the common good and of their contribution to attain it. However, a few express that not every student collaborates even though they could. The average in the Likert scale of the sub-competence of teamwork was of 4.18 /5.

The favorable and advantageous aspects of collaborative learning reveal strengthened interaction and communication, as per Garcia-Varcarcel (2012), and OER adding a motivational component to collaborative learning. The negative aspects identified in the survey, reported by 23% of the students were: disorganization, discussions, disagreements and students that do not work. These need to be solved by the teacher applying strategies to engage the student.

Thus, it can be concluded that the three specific objectives were fulfilled, moreover, the study allowed to identify competences directly related to technology-mediated learning environments, collaborative learning and mathematical competences. Said competences were expressed in terms of categories and indicators, but they are also framed in the official standards of MEN (2006).

Validity

The information collected in the research's fieldwork for the qualitative part was validated through triangulation, contrasting results obtained for each category, comparing what was obtained from interviews with the observations and the literature consulted. Observations were corroborated with teachers responsible for the observed classes. Internal validity from a qualitative perspective required attention to aspects proposed by Valenzuela and Florez (2012), such as: maturation, sensitivity to tests and deficient instrumentation. Since it is a descriptive cross-sectional research, other risks related to the manipulation of variables do not apply.

Instruments used were validated by previous studies. The study adhered to ethical principles and informed consents were voluntarily submitted.

The initial question was: What is the effect of using ICT-mediated OER in mathematics for comprehensive training of seventh grade students of basic secondary education?

The results of the instruments and its analysis, including triangulation, showed that students recognize that pedagogical use of OER in seventh

grade mathematics strengthens comprehensive competences, facilitates learning, promotes self-regulation, encourages development of logical mathematical thinking, fosters interaction between students and teacher, as well as sense of belonging to a community. These learnings and attitudes are found in the standards of competences by MEN (2006), as referred to before.

Future studies should delve into and look for strategies to strengthen competences of problem solving and negotiation, since the level reported by the Likert scale showed the lowest results for those competences.

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