

MOBILE-LEARNING MEDIATED WITH PACIE

METHODOLOGY FOR CONSTRUCTIVIST KNOWLEDGE

El mobile learning mediado con metodología PACIE para saberes constructivistas

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Abstract

In this article entitled Mobile-learning mediated with PACIE methodology (Presence, Reach, Training, Interaction, E-learning) for constructivist knowledge, the objective is to analyze how mobile devices contribute significantly to learning processes, benefit students and teachers to interact immediately in the construction of knowledge. In the proposed scenario, reflections of several modern researchers that support m-learning are considered, points of view that allow the analysis of conceptions to relate the processes of the PACIE methodology. This analysis will allow considering the use of mobile devices for e-learning. Indeed, it is looking at the gap between traditional education and mobile devices, the latter arouses interest in the mediation of learning between teachers and students. It also stimulates the sense of autonomous responsibility, supports and strengthens curricular and extracurricular teaching-learning practices from several innovative scenarios. The results show how learning is strengthened when interacting with the use of mobile devices, as it allows you to be connected anywhere and at all times. The main contribution of an article is the presentation of some innovation alternatives to improve the teaching-learning process based on the PACIE methodology. In addition, it will reflect on the teacher's vision regarding the use of technology.

Keywords

PACIE methodology, constructivist knowledge, m-learning, teaching-learning.

Resumen

El presente artículo titula el *mobile learning* mediado con metodología PACIE (presencia, alcance, capacitación, interacción, *e-learning*) para saberes constructivistas. El objetivo es analizar cómo los dispositivos móviles aportan en forma significativa en los procesos de aprendizaje, benefician a estudiantes y docentes a interactuar de manera inmediata en la construcción del conocimiento. En el escenario planteado se considera reflexiones de varios investigadores modernos que respaldan el *m-learning*, puntos de vista que permiten el análisis de concepciones para relacionar los procesos de la metodología PACIE. Este análisis permitirá considerar el uso de los dispositivos móviles para el *e-learning*. Lo que se quiere es mirar la brecha entre la enseñanza tradicional y los dispositivos móviles, este último despierta el interés en la mediación de aprendizajes entre docentes y estudiantes. Además, estimula el sentido de responsabilidad autónoma, y apoya y fortalece prácticas de enseñanza-aprendizaje curricular y extracurricular desde varios escenarios innovadores. En los resultados se evidencia cómo el aprendizaje se ve fortalecido cuando interactúa con el uso de los dispositivos móviles, pues permite estar conectado en cualquier lugar y en todo momento. El principal aporte de artículo es la presentación de algunas alternativas de innovación para mejorar el proceso enseñanza-aprendizaje con base en la metodología PACIE. Además, reflexionará sobre la visión del docente con respecto al uso de la tecnología.

Palabras clave

Metodología, PACIE, constructivismo, enseñanza, *m-learning*, aprendizaje.

Introduction

This article analyzes the significant contribution of the use of mobile devices for e-learning, that is, the transformation of traditional education into innovative learning for the digital age. A situation that will strengthen the networks of thought and learning communities in a perspective for the new virtual educational practice, so it is important to highlight that it becomes essential and necessary to align ourselves with new virtual



methodologies for modern pedagogical scenarios. In this case, there is m-learning that becomes the model of interconnectivity with the internet. In this reality, it is relevant to highlight that “the age of the internet demands changes in the educational world [...] this change is moving towards a new, more personalized educational connectivist paradigm focused on the virtual activity of students” (Marqués, 2012, p. 10). This new horizon immediately enhances online knowledge, whose well-used devices promote synchronous and asynchronous learning in technological pedagogical scenarios.

The objective of this article is to analyze m-learning mediated with PACIE methodology for constructivist knowledge, this will allow assessing modern educational trends in order to apply them in technological didactic scenarios through the use of smart mobile devices such as laptops, portable audio devices, iPods, smartwatches, gaming platforms, among others, whose purpose is to mediate the teaching and learning processes with the PACIE methodology. This methodology is considered the modern virtual constructivist pedagogical strategy for knowledge. With the presence of the object of learning, scope, training, interaction, and e-learning, the construction of knowledge in educational research and innovation contexts is strengthened.

Innovating in the construction of autonomous and collaborative learning is the main contribution of this article since it values the use of mobile devices for teaching. It is common to listen to teachers who say: ‘Do not bring cell phones to class’, from this idea our hypothesis is posed: Is the intervention of the internet through the mobile device, accompanied by the PACIE methodology important to strengthen constructivist learning?

Boosting constructivist learning from modern pedagogical settings will facilitate teachers and students rescuing previous knowledge, now called ‘inverted classroom’. This innovation consists of sending the link either from a video or perhaps from the document that you want the students to review, this process will allow requesting summaries to develop the new knowledge. What is intended is to promote autonomous and collaborative learning through several mobile devices.

The methodological framework we used is bibliographic research, through authors and organizations that support theories about the use of mobile devices such as: Chamocho (2016) that bases the origin of m-learning and its implementation in education; Santiago, Trbaldo and Kamijo (2015) who support the classification of mobile devices into three



broad categories; the National Institute of Statistics and Censuses (INEC, 2016) that presents information on the increase in the use of mobile devices in Ecuador; Ausín, Abella, Delgado, and Hortigüela (2016) confirm the use of mobile devices in learning; Camacho (2008) and its PACIE methodology for virtual learning environments; Mejía, Sánchez, and Vizcaino (2014) who indicate that learning is based on the experience's relationship; González (2016) and the dialectical or social constructivism; finally, the Technological Observatory of the Ministry of Education, Culture and Sports of the Government of Spain (2011) that mentions experiences of the use of m-learning and various educational applications for mobile devices. Based on the considerations above, relevant aspects of *mobile learning* are highlighted.

The investigation begins with the generalities of m-learning, classification of mobile devices, the use of mobile devices in Ecuador and the world, and mobile devices used in Ecuador with data from INEC. The study continues with the analysis of pedagogical advantages in educational processes through mobile devices in e-learning and the experiences of other countries with the application of the PACIE methodology. The article concludes with the presentation of some pedagogical innovation alternatives to be applied in virtual educational scenarios, one of them is the PACIE methodology. In addition, we reflect on the teachers' vision regarding the use of technology.

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Theoretical approach

Mobile learning or learning based on the use of mobile applications is considered one of the modern computing technologies that will have a great impact on educational innovation, which will allow transforming traditional education into modern. The mobile learning concept generates great expectations in the educational field, as it offers innovative methods to favor the construction of knowledge through the use of mobile devices such as smartphones, laptops, tablets, personal digital assistants (PDAs) and any other device that can be wirelessly connected. As indicated by Francisco Chamocho (2016):

The origin of m-learning and its implementation in education are closely linked to the evolution and convergence of three aspects that are: the development of mobile technologies, the new educational paradigm and the emergence of new forms of learning (pp. 13- 14).

The development of mobile technologies has allowed the evolution of ubiquitous communication so that people can access content and resources at any time, regardless of where they are. In reference to this new paradigm, there is a change in attitude in schools, colleges, and universities in which they consider the use of mobile devices as a technological resource with infinite possibilities for learning.

The emergence of new forms of modern learning has managed to meet the demands of technological education since it is easily learned through the internet without the limitations of time and place. Therefore, the use of mobile applications is considered as a modern learning innovation.

Some concepts related to m-learning

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M-learning is a teaching-learning methodology that uses all types of mobile devices with a wireless connection to allow access to knowledge from anywhere and at any time. UNESCO (2013) notes that:

Mobile learning involves the use of mobile technology, either alone or in combination with other information and communication technology (ICT), to enable learning anytime and anywhere. Learning can unfold in a variety of ways: people can use mobile devices to access educational resources, connect with others, and create content, both inside and outside classrooms. Mobile learning also encompasses efforts to support broad educational goals such as effective administration of school systems through the use of mobile devices (p. 6).

These perspectives of mobile contexts allow us to overcome geographical, economic, labor and personal obstacles, thus contributing to equal opportunities, since it allows people to connect with everyone, no matter how far away they are. It is an alternative to face the current situation and project the scope of motivational learning. In addition, it encourages teachers to plan, design, produce materials and various forms of tutoring. It represents the most important way of didactic dialogue or mediated communication because by its self-instructional nature it allows autonomous learning. In this regard, Salgado (et al., 2016) highlights the following:

Mobile learning is a set of teaching and learning practices and methodologies using mobile technology, that is, using mobile devices with wire-

less connectivity. It would be the combination of e-learning or learning through the internet, with mobile devices to produce educational experiences in any situation, place and time, moving the educational processes to a new dimension by being able to cover urgent learning needs, anywhere and with great interactivity (p. 4).

For Pacheco and Robles (2006), they affirm that “m-learning corresponds to the sum of learning plus mobile devices and more wireless network” (p. 6). Similarly, the Spanish Ministry of Education (2012) states that:

This educational methodology allows both the teacher and the student to maintain constant contact at any time of the day, thereby promoting an individualized education and adapting to the needs of the student at all times (all people are not motivated at the same times of the day) and so with a long etcetera of advantages (p. 1).

Therefore, it can be noted that mobile learning positively influences student interest, which means that many aspects of the teaching-learning process can be developed efficiently, with these modern virtual scenarios. In the same way it allows the student to build knowledge, skills and digital skills at any time and in any place.

Mobile devices

It is a portable instrument that has processing capabilities, storage and internet connectivity that is used for certain tasks. In general, Santiago emphasizes that mobile devices are classified into three broad categories: the first limited data mobile devices specified by having small text-type screens and data services limited to SMS and WAP access; the second basic mobile data device is characterized by medium-sized screens whose navigation is based on icons and allows access to email, SMS, web browser, etc.; the third kind is an improved mobile data device that has medium or large touch screens, has applications such as Microsoft Office, corporate applications, internet portals and operating systems (Santiago et al., 2015, pp. 14-15).

The operating systems used for mobile devices are many, but there are two that are the main ones and that occupy almost the entire market: iOS and Android, followed, but by far by Symbian, BlackBerry OS, and Windows Phone. The main feature of mobile devices is the mobility they



offer since they are small devices that can be carried in your pocket and are also easy to use.

These devices also allow you to connect them to a computer to be able to interact with the processing, storage, and connectivity. Another feature to note is that these devices allow connection to a wireless network.

Types of mobile devices

Currently, there is a wide variety of mobile devices that can be carried from one place to another and that are easy to operate. Now, from the analysis of the work of Santiago (et al., 2015), the following types of mobile devices are determined:

- *Smartphones*: It is a type of mobile phone that has the ability to process and store information similar to a minicomputer. Smartphones allow mobile connectivity and application execution for countless activities such as the use of email.
- *Portable game console*: it is lightweight electronic; it can be used for video games. In this portable device the screen, controls, audio, and battery are integrated which allows the user to be connected at any time and from anywhere.
- *Personal digital assistant (PDA)*: personal pocket digital assistant.
- *Pager*: It is a telecommunications device that receives short messages.
- *Laptop*: It is a small type of computer designed to be moved from one place to another and that allows processing and storage similar to that of a desktop computer. Laptops, unlike notebooks, allow more advanced processing and storage.
- *Ultra-Mobile PC*: It is similar to a small format tablet, they have good processing capacity for text, audio, video, communication, and network editing.
- *Tablets*: It is a device larger than a smartphone or a PDA. This device has a touch-screen that allows interaction without the need for a physical keyboard or mouse, they also have more advanced features for both processing and storage (pp. 21-31).



Figure 1
Types of mobile devices

Smart phones	
PDA	
Pager	
Portable game console	
Tablets	
Laptop	
Ultra-Mobil PC	

Source: the authors

The use of mobile devices in Ecuador and the world

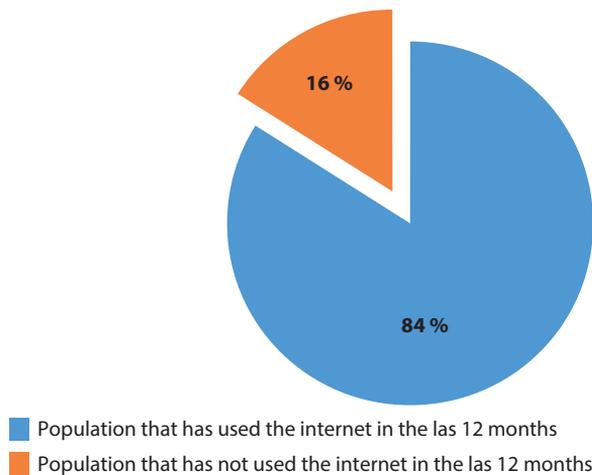
The use of mobile devices has been growing vertiginously worldwide, and Latin America could not lag behind this technological revolution that covers the entire world, according to Viracocha (2017):

There are more than 630 million mobile connections, which place Latin America in the third-largest mobile phone market worldwide. Among

the mobile devices that register greater connections to the network are smartphones, tablets and laptops, and specifically smartphones because new models of equipment offer higher performance and allow to meet the increasingly demanding needs of users (pp. 41-42).

In the National Multipurpose Household Survey of INEC (2018), the use of mobile devices in Ecuador has increased rapidly, so that by the year 2018, the acquisition of laptops in homes has increased 10.3 points and in five years has reached 24.2%” (p. 5). INEC issues another interesting figure for Ecuador: in 2018 55.9% of the Ecuadorian population evidenced that they use the internet in the last year. In the urban sector, there is greater internet usage than in rural areas (p. 12).

Figure 2
Percentage of people who have used the internet in the last 12 months

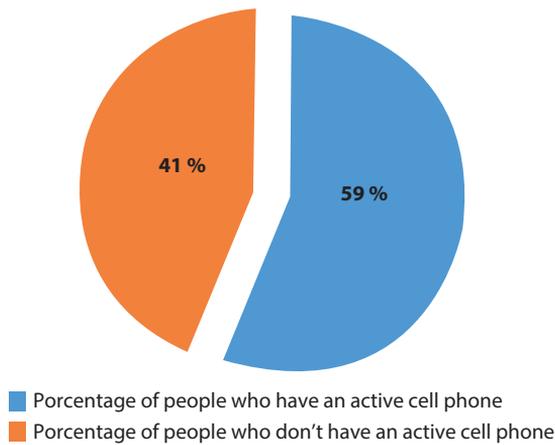


Source: the authors from INEC, 2018, p. 17

According to the National Multipurpose Household Survey of the INEC (2018), the data regarding cellular telephony indicate that: 90.1% of Ecuadorian households own cellular telephony, of which 59% have at least one activated cell phone. Another important fact is that the age group with the highest use of activated cell phones is the population that is between the ages of 25 and 34 followed by the population that is between 35 and 44 years (p. 21).

Figure 3 indicates the percentage of people who have an activated cell phone:

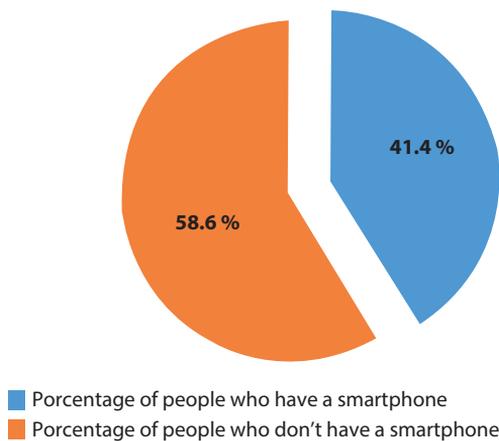
Figure 3
Percentage of people who have an active cell phone



Source: the authors from INEC, 2018, p. 19

According to data from the same survey (INEC, 2018), the segment of the smartphone “grew 4.2 points compared to 2012, that is, it rose to 41.4% of the population having a smartphone” (p. 23).

Figure 4
Percentage of people who have a smartphone



Source: the authors from INEC, 2018, p. 23

Based on the previous data on the use of mobile devices and specifically smartphones, Ecuador has had accelerated growth in accordance

with what happens in the rest of the planet, since it is a global trend. The use of mobile devices allows you to better perform daily activities and learning can also become a daily activity.

Trends in the use of portable devices in learning

ICT has allowed us to witness an important transformation in the educational field, however, the desired levels have not been achieved, since in some cases the traditional teaching-learning models have simply been moved to current technologies. Thus, according to Ausín (et al., 2016):

Adequate use of ICT should be established and the teacher encouraged to create their own teaching resources, based on the characteristics and needs of the student, and fundamentally with an appropriate instructional design to generate self-learning and achieve learning milestones (p. 31).

In response to these trends, Jaramillo and Simbaña (2014) indicate that “the use of ICT in education reduces the obstacles that arise in the pedagogical process” (p. 302), that is, it leads teachers to design teaching resources to ensure that programmatic content is motivating, in accordance with the new digital era. Therefore, “the use of ICT in education provides a number of tools, resources, media and formats that enable teaching strategies to facilitate the construction of knowledge” (Basantes et al., 2017, pp. 3-4). However, success depends on achieving the integration of technology in all educational settings so that the pedagogical classroom becomes a collaborative learning environment. Similarly, Ramírez (2009) mentions that:

When incorporating technological resources in learning environments, the advantages of providing greater flexibility for access to educational content [...] are evident, so the use of technological resources in the classroom is an important contribution in the process of teaching-learning that leads to increased student motivation (p. 71).

Then, the increase in the use of mobile devices has become a significant asset in recent years and should be used to a great extent to strengthen contemporary learning, as it will respond to the educational demand of the current times. Thus, Shuler (et al., 2013) indicates that:

As the power, functionality, and affordability of these devices increase, their ability to support learning in new ways also increases, therefore mobile learning provides advantages such as the flexibility of access to information at any time and place, favors autonomous learning and teamwork,



promotes the creation of learning communities and encourages effective active communication in a synchronous and asynchronous manner (p. 1).

In summary, the challenge for teachers according to what was stated by Abreu (2017) is “to take advantage of the potential of mobile devices to stimulate student learning through a didactic conception that allows us to overcome existing contradictions of the traditional model” (p. 2), that is, at the present time, they are a tool with a great educational potential at the service of current education, the same process that contributes to the technological teaching dynamic.

Advantages of using mobile devices in classroom-pedagogical scenarios

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According to the analysis of the article “Guidelines for mobile learning policies” (UNESCO, 2013), the following advantages can be mentioned when using mobile devices in teaching-learning processes:

Figure 5
Advantages of using mobile devices in the classroom

- Learning anywhere and at all times
- Greater scope and reach opportunities
- Facilitates collaborative learning
- Greater portability and functionality
- Maximum cost-effectiveness
- Continuous learning improvement
- Effective use of time
- Ease for personalized learning
- Enable instant interaction between teachers and students
- They allow greater accessibility
- Increased penetration
- Mayor penetraci3n
- Most economical technology

Source: the authors from UNESCO, 2013, pp. 9-28

To realize the advantages offered by mobile learning, policy formulation is recommended. In that regard, UNESCO (2013) notes the following measures:

- Create policies related to mobile learning or update existing ones.
- Train teachers to promote learning through mobile technologies.
- Provide support and training to teachers through mobile technologies.
- Create pedagogical content for use on mobile devices and optimize existing ones.
- Ensure the gender equality of students.
- Expand and improve connectivity options ensuring equity.
- Develop strategies to provide equal access for all.
- Promote the safe, responsible and healthy use of mobile technologies.
- Use mobile technology to improve communication management and education.
- Increase awareness about mobile learning through promotional activities, leadership, and dialogue (pp. 29-39).



Through the aforementioned policies, it can be determined at personal discretion that a characteristic feature of education may be the teacher's non-presence because connectivity encourages autonomous learning. The use of mobile devices certainly covers the needs of a massive dispersed population, in this sense, the only thing that should be guaranteed is the efficient use of these digital devices.

PACIE Pedagogy

Presence, scope, training, interaction, e-learning (PACIE in Spanish) is “a methodology that allows the use of ICT as a support to the teaching-learning processes that enhances the pedagogical structure of real education” (Camacho, 2019, p. 20). The new technological tools, since their inception, have become materials to be used in the process of student learning because they offer the ability to interact between students and teachers, where not only learning is developed, but also the sequence of knowledge is strengthened.

The PACIE methodology establishes the following phases:

- *Presence*: this first phase intends to create the need for the student to enter the virtual learning environment, that is, it seeks

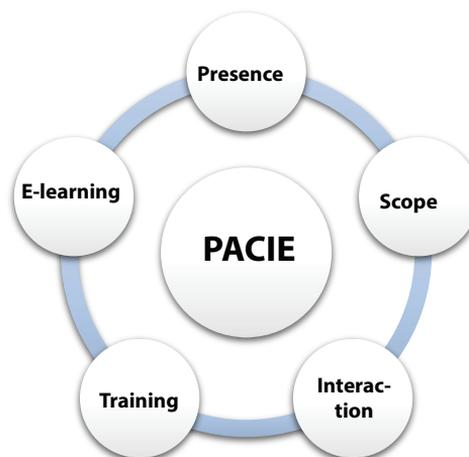
the student to be interested in the contents found in the virtual classroom. As Fierro (2015) points out, “the main objective of this phase is to implement a corporate image of the virtual learning environment that captivates students because of its interactivity and design” (p. 66).

- *Scope*: this phase consists of the definition of the objectives that will be achieved with the students on the virtual learning environment. The objectives include communication, information, support and interaction. There are three types of objectives: academic, experimental and tutorial.
- *Training*: promotes self-learning and motivation of students with the aim of stimulating the use of virtual resources and tools that allow them to acquire the desired knowledge.
- *Interaction*: Emphasizes the generation of knowledge through practice through the use of resources and activities developed in the virtual learning environment. It seeks to generate in students the skills that allow them to build their own knowledge to socialize and share information.
- *E-learning*: is to use all the technology that is available to everyone with the aim of generating interaction and knowledge in students within the virtual learning environment.

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Figure 6
PACIE methodology phases



Source: The authors

The use of PACIE in virtual learning environments allows the integration of communication, exposure, and information through ICT. The objective is to generate interaction and collaboratively create knowledge.

The constructivist pedagogical model and its relationship with mobile learning

The constructivist version demarcates a process of personal-collective construction of new knowledge from existing knowledge in collaboration with colleagues and the facilitator. The constructivist model consolidates in the student the understanding of meaningful knowledge to solve some problematic situation, based on problem-solving skills.

It is mistakenly considered that constructivism leaves students free to learn at their own pace. In this regard, Ortiz (2015) notes:

In fact, what constructivism seeks is that there is an interaction between the teacher and the student, a dialectical exchange between the knowledge of both in such a way that a productive synthesis can be reached for both the student and the teacher (p. 93).

Therefore, mobile learning is a teaching-learning methodology that uses all kinds of mobile devices with a wireless connection to allow access to knowledge from any place and at any time. As noted by Brazuelo and Gallego (2011):

Mobile learning is an educational model that facilitates the construction of knowledge, the resolution of learning problems and the autonomous development of diverse skills or abilities through the mediation of mobile devices (p. 1).

Mobile learning are handheld mobile devices that have wireless connectivity. This type of connectivity allows for establishing space-time flexibility. The main advantage lies in the ease of everyday communication. This type of technology motivates students to learn.

The use of mobile devices, especially the cellphone, has been listed as an intruder in the classroom. However, it should be considered that children and young people currently use it daily, at all times and places. Mobile learning is presented as a new teaching process. Learning methods change radically due to technological advances and the dynamic nature of students. This is how Mejía (et al., 2014) indicates that:

Specifically, with smartphones you learn everywhere, in this way the student is conceptualized as a strategic agent that causes change and is



not waiting for the teacher to tell him what to do in his learning, this is how teachers become facilitators for the student to reach higher levels of knowledge through the use of mobile devices (pp. 7-8).

Mobile devices certainly cause changes in curriculum planning. These changes lie in the improvement of teaching materials since the teacher is forced to design learning tools, it is a way out of the comfort zone, since it was thought that presenting information on slides or Prezi was enough. The goal is to innovate in functions that attract students, as do the most famous video games or YouTubers in the world.

Ubiquitous learning for constructivist knowledge

Ubiquitous learning refers to the learning environments that can be accessed in different scenarios and situations, that is, it is learning that occurs anywhere, anytime. Ubiquitous learning underpins much of Vygotsky's proposal in dialectical or social constructivism. González (2012) indicates that "the knowledge generated will then be the reflection of the external world influenced by culture, language, beliefs, direct teaching and relationships with others" (pp. 23-24). With this assessment, it is determined that to learn one needs a cultural environment and interaction with others, because it is a social process.

In social constructivism, the role of the teacher is fundamental since it must consider the ecosystem and cultural identity that lead to the strengthening of customs, traditions to give new and transformed responses to the problems and challenges of interculturality, returning the leading role of the teacher in the social co-responsibility.

From the above, virtual learning is the connection between several groups of students in various pedagogical scenarios, even provoking the collaboration of distant people, which allows integrating the principles of constructivist learning. This causes updated social and learning.

Significant educational experiences of mobile learning in other countries

Currently, there are many educational experiences on the use of mobile learning for educational processes. In this regard, Olmedo (2016) notes:

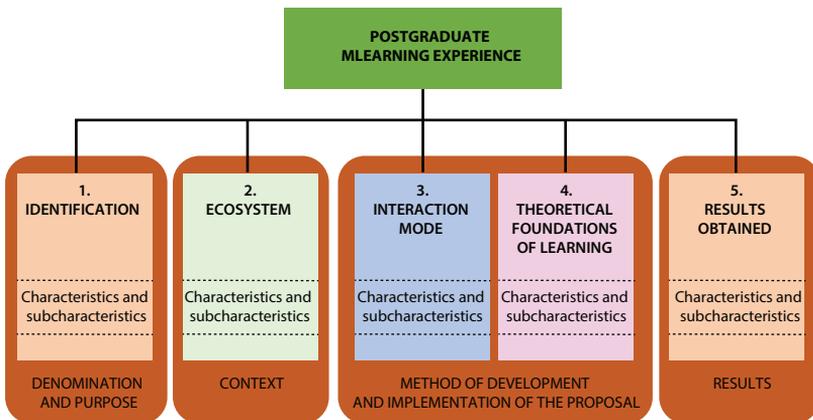
- *MATI-TEC: Mobile learning for development and inclusion*. According to Olmedo (2016), it is a project funded by the Telefónica Foundation of Spain and developed by the Monterrey



Institute of Technology and Higher Education, to improve the mathematical, reading-writing and technological skills of elementary school students in Mexico. MATI-TEC is a mobile application that supports the teaching-learning process and is used with students for accompaniment and participation inside and outside the classes. The educational community of the beneficiary schools intervenes. It is a comprehensive training project that is essential to achieve the objectives set within the teaching-learning process (Olmedo, 2016, pp. 7-13).

- *MADE-mlearn*. According to Herrera (et al., 2013), it is a project that envisions a scenario for the analysis, design, and evaluation of m-learning experiences at the graduate level. Based on their own background and a bibliographic review to investigate the subject. It is a proposal with theoretical emphasis that allows us to identify and characterize the experiences or projects of m-learning from the use of a series of attributes grouped into categories, which respond to axes of analysis. Methodologically, it is a framework supported by the study of previous work at the national and international level on educational practices and fundamentals linked to m-learning. Figure 7 shows the axes and categories for the analysis of m-learning experiences at the graduate level (Herrera et al., 2013, pp. 7-15).

Figure 7
Axes and categories of MADE-mlearn



Source: Herrera et al., 2013, p. 5



In addition, other educational experiences of the use of mobile learning can be pointed out, according to the analysis of the article “Mobile learning” of the Technological Observatory of the Spanish Ministry of Education (2011): at the University of Malaga, they have created pedagogical micromodules for mobile phones focused on Wap2 wireless technology. These educational scenarios complement the student’s training, through the classroom and the contents of the virtual classroom available via the internet. At the formal level they share the same design, characterized by its simplicity, but offer specific resources for each subject ranging from tests, animated graphics, glossaries, etc. The M-Learning Project jointly carried out by researchers from Italy, Sweden and the United Kingdom tries to use portable technologies to provide digital literacy and learning experiences for young people between 16 and 24 years of age. Mobile Autor is an application that helps teachers create and maintain their courses on virtual platforms. The AMB Project presents a dynamic that incorporates mobile video games for the development of problem-solving capabilities and concept learning (Ministry of Education, 2011, pp. 17-18).

All these applications of mobile devices made in other countries will serve as experiences to extrapolate in Ecuador. In addition, we must take advantage of new possibilities to learn through new scenarios of modern knowledge.

Uses in educational practice

According to the analysis of the article “The best educational applications on Android” from Spanish Ministry of Education (2012), are the following:

Table 1
Useful applications in educational practice

Type	Application	Academic Area
Language learning	Babel. It allows language learning: German, French, Spanish, English, Italian and others.	Languages
	Voxy. Allows online teaching of the English language.	
	Bussu. Learning the English language.	
	Verbos españoles. It allows to consult conjugations of verbs, includes grammar and a search engine for translations	
Scientific and mathematical field	Solution Calculator Lite. It allows calculations for chemical solutions.	Chemistry

	Periodic table. It shows the elements of the periodic table.	Chemistry
	Anatomy 3D Free. For learning the anatomy of the human body.	Natural Sciences
	HandyCalc Calculator. Graphing calculator allows solving arithmetic and trigonometric operations, equations, exponential functions.	Algebra
	Google Maps. It enables locating anywhere on the planet, and display personalized information.	Social Sciences
	Google Earth. Through maps discover and explore cities and places around the world.	Social Sciences
	Países del mundo. It allows to discover geographic data: capitals, populations, situation, languages, flags of any country in the world.	Social Sciences
	Earth Now. It allows to see and manipulate a 3D reproduction of the globe.	Social Sciences
	Art Academy. It provides a virtual art gallery where there are more than 4,000 paintings by 700 different artists and 300 museums.	Social Sciences
	SkyMap. Constellations, stars, and planets are displayed.	Social Sciences
	TED. It is an application that integrates videos and audio of famous people in different fields of culture, technology, science, etc.	Social Sciences
Educational organizers and managers	Kingsoft Office (International). It is compatible with Microsoft Office which allows you to open and edit any text document, spreadsheets, presentations, etc.	General
	Edmodo. Application designed for mobile devices in teaching scenarios. It allows for creating different groups and sharing with them any type of information, educational material, work, alerts, events, etc.	
	Cuaderno del profesor. It enables optimizing the tasks: courses, schedules, personal agenda, records of evaluations, assistance, etc.	
	Homework. It serves for the teaching organization of schedules and tasks. Register: subjects, schedules, homework, and exams.	
	Ankidroid. Application to create flashcards, allow to memorize: languages, geography, names, works, etc. In addition, it allows the inclusion of images, audios, and videos.	
	Catch. Organizer of ideas, it allows the creation of notes.	
	Any.do. Task manager, allows you to take all kinds of notes, create lists (folders) and set alarms.	



Educational games	Apalbrados. Crossword game available in several languages.	General
	Holoholo. Use geolocation to show the most emblematic places in a city.	
	Wordshake. It is an interactive game that allows you to form words in English but against the clock.	
	Sudoku 10000. It has a great variety of interactive games.	
	Trivial Gems. It contains games of trivia.	
	Riddle Pic. It used for trivia games with questions about educational content seen in class such as characters, countries, flags, works of art, etc.	
	Ahorcado. It is an interactive game in which a word must be discovered before the drawing of a doll is completed.	
	Letrastro. It is an interactive game that requires the search of the greatest number of words against the clock.	

Source: the authors from the Spanish Ministry of Education, 2012, pp. 10-61



Conclusions

Currently, there is a large number of mobile devices connected worldwide, in a larger proportion are smartphones, so it is vital to use and strengthen the use of mobile learning in education. Mobile learning will allow one to improve learning due to the incorporation of mobile devices, as it allows one to be connected anywhere and at any time.

In Ecuador, there are meaningful figures, according to data from INEC (2018) the segment of the smartphone “grew 4.2 points compared to 2012, that is, it went to 41.4% of the population that has a smartphone” (National Institute of Statistics and Census-INEC, 2018, p. 23). This means that the use of mobile devices and especially smartphones, has increased in recent years, becoming a modern social and learning tool, with which simply connecting to the internet, from anywhere, facilitates autonomous and collaborative learning by promoting computational thinking in learning networks.

The PACIE methodology strengthens communication, collaborative learning and the organization of constructivist learning in a technological way, becoming social processes that contribute to significant learning by strengthening learning communities. Therefore, this methodology when applied in virtual pedagogical scenarios, becomes a motivating instrument for the development of knowledge. Ubiquitous learning is based on social constructivism, in which interaction with the

environment and the relationship with others is fundamental, and that is where the use of mobile devices facilitates students to develop knowledge, skills, and attitudes.

Worldwide there are several educational experiences of the use of mobile learning in teaching-learning processes. The results have been favorable, both for students and teachers because it has been observed that technology becomes a training tool for the construction of knowledge.

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