Modalidades de cognición en un curso universitario basado en el aprendizaje móvil

Cognitive modalities in a course based on mobile learning

http://dx.doi.org/10.32870/Ap.v10n1.1159

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Palabras clave
Aprendizaje móvil, cognición distribuida, cognición empírica, dispositivos móviles

RESUMEN

Este artículo tiene como objetivo explorar las modalidades de cognición involucradas en un curso universitario basado en el aprendizaje móvil. La pregunta de investigación cuestiona las modalidades de cognición asociadas con el uso de dispositivos móviles en un curso universitario. Para responderla, recurrimos a un estudio de tipo exploratorio, con enfoque cualitativo y diseño de estudio de caso con múltiples unidades. La muestra estuvo compuesta por 53 estudiantes de la carrera de Ingeniería en Gestión Empresarial del Instituto Tecnológico de Hermosillo. En la recolección de datos aplicamos la entrevista semiestructurada, la observación participante, la encuesta y el análisis de documentos secundarios. Los datos fueron analizados mediante codificación lineal y axial. Los resultados muestran el predominio de modalidades de cognición como la empírica y la cognición distribuida, que contrastan con los resultados de otros estudios sobre aprendizaje móvil y desarrollo de habilidades cognitivas. Concluimos que el aprendizaje móvil privilegia una cognición de tipo empírico, centrada en la ejecución de procedimientos que oscilan entre una actividad mental de tipo algorítmico y otra de tipo heurístico.

Keywords
M-learning, distributed cognition, empirical cognition, mobile devices

ABSTRACT

The objective of this research was to explore the function of smartphones in the modes of cognition. The research question refers to the modes of cognition associated with the use of mobile devices in a university course. To answer this inquiry, we used an exploratory type study, with a qualitative approach and design of case study with multiple units. The sample consisted of 53 students of the degree in Engineering in Business Management of the Instituto Tecnológico de Hermosillo. To collect the data we used the semi-structured interview, the participant observation, the survey and the analysis of secondary documents. Qualitative data were analyzed using linear and axial coding. The results show the predominance of knowledge modalities such as empirical cognition and distributed cognition, which contrast with the results obtained by other studies on mobile learning and the development of cognitive skills. We conclude that mobile learning induce an empirical cognition, based on the execution of procedures that oscillate between the algorithmic and the heuristic mental activity.

Received: May 31, 2017
Accepted: September 14, 2017
Online Published: March 30, 2018

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INTRODUCTION

In contrast with the linearity of the text of a book and the access to the knowledge that this support provides, based on inductive and deductive reasoning as well as on the in-depth analysis and reflection, a digital mean such as the *smartphone* configures an interactive tactile surface. In the latter, the text becomes reticular and is no longer the information main support. It is its combination with the image that, through icons and visual interactive models, offers a different learning experience based on a cognition mode in which the exploration and the experimentation with digital models predominate.

The emergence of an alternative cognition form fostered by digital means which Serres (2012) calls algorithmic or procedural, tends to be favored by the younger generations over memorization and conceptual abstraction privileged by the book. The way a student learns, with the support of a mobile device, remits to heuristic methods used by engineers to design and develop prototypes. It involves experimenting in a direct manner through the interaction with the learning mediator object. Mobile devices seem to play this role through free access to academic-type information, as well as experimentation with pedagogical purposes.

On the other hand, the mobile learning resource encourages students to use a series of didactic resources and sources of information that are not confined to the classroom or school environment, but are rather distributed in different places outside the university environment. Such are databases, web sites, experts, friends, etc. This distribution of information in different places and contexts tend to enrich the possibilities of access to processing and converting said information into knowledge.

The foregoing situation added to the fact that mobile devices, as the name implies, give access to the information contained on the Internet in any place and time provided one has the corresponding connection while enabling the individual to move through a variety of contexts. Moving through changing contexts grants this educational modality a unique quality which is not present in other learning tools or means with the corresponding pedagogical consequences that are barely starting to be explored.

It is possible to perceive the potential of this technology that questions the classroom confined space and poses the possibility to learn from a large variety of situations through actions nestled in a context (Maciotra, Roth & Morel, 2008) and the face-to-face or at distance collaboration of the apprentices.

In this study, we will describe the cognition modalities present in mobile learning in a university course as well as the type of learning practices set into action by the students. We are seeking to respond to the research

question: What are the cognition modalities associated with the use of mobile devices in a university course?

It is evident that we need to carry out a large number of experiences that allow constructing the concepts and models as well as identifying the theories that guide the teacher's practice in this field where information and communication technologies are emerging in education. This requires more specifically delving into explaining the role mobile devices performed during the teaching-learning process, the type of practices implied with their respective cognitive modalities, as well as the interaction patterns the students establish among themselves and these devices during said process, with this aiming at attaining a pedagogical objective.

THEORETICAL FRAMEWORK

In spite of the fact that a qualitative study does not generally use a theoretical framework, using this element was made in function of relying on a theory that guides the research and poses the corresponding question according to the role Cresswell (1994) assigned to the theory of qualitative studies. In this section, we will tackle mobile learning briefly and next, we will address the concepts of enaction and distributed cognition which will help better comprehend the results obtained in the field research.

Mobile Learning

There is no unified definition of the mobile learning concept; the most common one is that it is centered on mobility and ubiquity, both linked to the technological aspect of mobile devices. Traxler (2005), among others, defines mobile learning as any form of education resorting to mobile devices. Al Hamdani (2013) explains it as the mediation of mobile devices in the teaching-learning process. This technological conception has given rise to experiences that emphasize the device more than the pedagogy (Daughtery & Berge, 2017).

The technological connotation of the concept has been questioned at a later scale by Traxler (2007) himself who highlights the need to look for a definition focused on the experience of the apprentices more than on technology. However, as Pollara (2011) points out, a definition of mobile learning from the student's experience is presented more as an arduous task given the difficulty to incorporate in said experience the multifunctionality of this type of devices.

In a version that is in line with the orientation of the current studies on mobile learning that tends to focus the attention on mobility and multiplicity of contexts where mobile learning occurs, several authors describe it in terms of knowledge that can be obtained as a result of the interaction between the individuals and the devices through a diversity of

situations, and they emphasize the relation between learning and context (Baccari *et al.*, 2016; Yot & García, 2015).

In regard to the cognition modalities implied in mobile learning, object of this study, part of the researches conducted from this perspective focus on the development of cognitive skills (Churches, 2009), more specifically on those that require solving problems. Along these lines, Hwang and Chang (2011) point out that in a mobile learning environment aiming at the formative assessment that combines elements of both the real and virtual world, the students' learning improves since they are motivated in solving problems on their own.

In this research on the development of cognitive skills through the use of mobile devices with students of higher education, Ramos, Herrera and Ramírez (2010) found that this educational modality benefits the development of basic and higher cognitive skills, more specifically, those aiming at problem solving, decision-making, critical and creative thought, as well as the improvement in performing activities. Fuad, Deb and Whitaker (2014) add that, besides facilitating problem solving, the use of apps improves content retention and students' participation.

In another study that addresses the solution of a clinical case by medical students through learning based on problems and the use of mobile devices, Chávez, González and Hidalgo (2016) inferred that both strategies are compatible and become mutually enhanced with positive results. Sánchez and Olivares (2011) obtained similar results using games in mobile devices. According to these authors, the capacities in problem solving and the cooperation of the students improved. Therefore, mobile learning helps develop higher cognitive skills necessary to problem solving such as analysis or assessment, among others.

However, Yen and Lee (2011) found that students who use mobile technology and the Web in an intensive manner to learn through problem solving show a superficial capacity more specifically in regard to comprehension and planning as well as assessment and reflection; at the same time, students unlock operative-type skills.

Along these lines, Vargas, Gómez and Gómez (2013), in a study assessing the impact of mobile learning on the development of cognitive and technological skills with undergraduate students, found that this educational modality fosters basic and medium-type cognitive skills according to Bloom's taxonomy. Such is the case for comprehension, application and analysis. However, higher skills such as assessment and creation, both linked to critical and creative thought, are driven to the background.

On the other hand, as Zydney and Warner (2017), in a revision of the literature on university students between 2007 and 2014 using mobile applications for learning science, caution on the use of said applications

since they aim most generally in measuring the students' basic scientific knowledge or conceptual comprehension instead of developing higher cognitive skills; hence the need to do more research on this topic.

Enaction

Varela, Thomson & Rosch, 1992, provide a theoretical referent of the cognitive theory of enaction to describe the way in which mobile learning can function when an apprentice is immersed in an environment equipped with mobile devices and with which he interacts intensively.

Enaction, within the enactive approach to cognition, or act of "making emerge", is a term used by Varela (1996; Varela *et al*., 1992) to designate the fact through which an observer, from a common background or context together with recursive interactions with the environment, makes an interpretation or meaning emerge that allows him to adapt to said environment. (Maturana, 1992). By interpretation, we understand the capacity of an organism to make a sense emerge in its way of operating with the environment from a comprehension or common sense background.

As Varela (2003) points out, the cognitive approach of enaction assumes that the perception and the action, from a cognition standpoint, are inseparable. There is no independent reality of the cognizant subject from which the latter extract a series of representations with the purpose of acting on the former, as postulated by the vision of classical epistemology that separates the subject from the object. What exist are actions guided by the perception and organized in recurrent sensomotor patterns that produce cognitive structures called knowledge. This sensomotor structure of the individual is the starting point of the embodied action which guides the action of the subject in the environment, an environment which now depends on the individual inasmuch as it transforms him and is transformed by the individual, as proven by Piaget (1981).

From the perspective of the cognitive approach of enaction, knowledge is something dynamic that is permanently transforming and not a fixed entity constructed through the action of the subject and, then, stored in his memory. Hence, learning in education is generally considered as an active process. However, as Maciotra *et al.* (2008) point out, the product of this process is considered fixed, acquired. From the logic of enaction, the resulting knowledge is also a changing process, in constant evolution that, at a given time, someone decides to stabilize it with the purpose of representing and transmitting it.

This approach of cognition that emphasizes the experience of the human being is particularly interesting in understanding the way in which youngsters interact with mobile devices. Enaction highlights a form of

empirical[1] or experimental cognition in which the action is guided not from an idea or prior concept but rather from sensomotor patterns related with the peculiarities of the environment (Clark, 1997). The *smartphone*, considered as the mean, is transformed as the student explores the app it contains; likewise, the latter transforms the cognitive structure of the student until knowledge emerges.

Therefore, the self-regulated learning process is given precisely through this dance or structural mating (Maturana, 1992) between the student and his environment which, in this case, is represented by the *smartphone*. For Varela (2003), "the most familiar cognitive structures of the human life emerge from different types of sensomotor models that allow the action to be guided perceptually" (p. 34).

Sensomotors or embodied structures, as is the case of the oculomotor coordination the student displays in manipulating the *smartphone* and navigating through the app, allow organizing his learning experience in knowledge that can emerge or not, depending of his capacity to shape said experience. "Cognitive structures *emerge* from recurrent models of sensomotor activities" (Varela, 2003, p.36). Acting permanently with the environment or mobile device lead to make knowledge emerge or enact. Varela (2003) adds that cognition "is not constituted by representations but rather by *embodied actions*" (p. 39).

Since the individual is one with the environment, the result of his action does not reside in his body only but also in the elements of the environment. This conception of cognition as something enacted by the action of an individual and distributed in the environment is what Hutchins (1993) calls distributed cognition.

Distributed Cognition

Learning, as a process that implies a more or less intense cognitive activity, supported by strategies and techniques, as well as tools, symbolic as material, is conditioned by the use of technical devices that supports it. From this conception of socio-cultural constructivism, it follows that cognition is not confined to the mind of the apprentice but is rather distributed in the environment with which he interacts (Pea, 2000) through the resource of tools that are also an integral part of this environment.

Distributed cognition, also known as extended cognition or externalism in regard to the mastery of knowledge within cognitive sciences, arises from the emergence in the last century of disciplines such as cybernetics, general systems theory and information theory. However, this distributed or multidimensional conception of cognition had been raised by Vigotsky

[1] El término empírico (*emperikos*) se utiliza aquí en su doble acepción de práctica y experiencia, así como de experimentación.

(1988) at the beginning of the 20th century, when he pointed out that basic actions such as making a knot or making a mark on a piece of wood with mnemomic supports, extend the biological functions of the nervous system outside the body.

Distributed cognition as a general reference framework was formulated by Hutchins (1993) from the assumption that cognition is located in the world and not only in the mind of the individual. Therefore, the knowledge necessary to perform a task is distributed through individuals, artifacts and tools of the environment. The latter are considered products of the human culture.

The learning environment within which the student relates and evolves is made up by a diversity of actors: students, teachers, school authorities as well as didactic materials, books, computers, software, Learning Management System (LMS) platform, laboratories, notebooks, curricula, etc. Such conglomerate forms a complex network that can be visualized as a transforming flow and permanent changes in function of a pedagogical objective.

People, as pointed out by Salomon (2000), "seem to think in conjunction or in association with others, and with the help of tools and means provided by the culture" (p. 13). An individual never thinks in an isolated manner but rather with the support of his social and physical environment more specifically with the assistance of technology. Knowledge is distributed.

METHODOLOGY

This is an exploratory-type research with a qualitative approach and design of case study with multiple units (Stake, 1999). This research aims at generating a theory (Glaser & Strauss, 1967) on mobile learning.

The research poses the following question: What are the cognition modalities associated with the use of mobile devices in a university course? The purpose of this study consists in identifying those cognition modalities as well as the learning practices that derive from this educational modality.

Sample Description

For convenience, we use a non probabilistic sampling (Cresswell, 1994), by which we selected two groups of students from the eighth semester of Business Managerial Engineering of Instituto Tecnológico de Hermosillo [Hermosillo Technological Institute], in the context of an electronic marketing course during the 2016 January-June semester.

The course pedagogical objective consisted in developing an electronic marketing strategy based on a market study that included the design of an

electronic trade site, the design of an app to position the brand, as well as the design of advertising for social networks through the Internet.

The groups are morning students and are the only ones of their generation. Both groups show a certain degree of homogeneity in regard to the 22 years age average, middle class socio-economic strata and their level of knowledge and skills recognized by the admission exam from the Centro Nacional de Evaluación para la Educación Superior (Ceneval, [Spanish acronym for the National Higher Education Assessment Center], 2012).

In total, 29 students were registered in the G8A group and 24 in the G8B. The 53 participants were organized in 15 work teams with an average of three to four members each. From these, we selected six which were studied as similar cases in a multiple cases design. The selection followed the maximum variation criterion in accordance with the level of performance shown (high, medium or low) during the two first months of the teams' activity.

METHODOLOGY

Collective work is already difficult to produce in almost any learning environment imaginable. Thus, when talking about LVE, the elements that ought to be considered in proposals for the construction of collaborative activities are even more important, given that, in addition to the design of the activities themselves, it is essential to select technologies that are adequate to the task of generating communication and giving impetus to the appropriation of common space. Wenger mentions three elements that are basic for the construction of community: shared understanding (which is constantly renegotiated by its members), mutual commitment that unites its members in a cohesive group, and a shared repertoire of common resources that result from shared practice (Wenger, quoted in Gros, 2011). Analyzing with greater detail what these three elements represent, we identified that in all of them it is necessary for communication to be constant and efficient, in the sense of a real construction of dialogues, where there are exchanges of opinion and doubt, as well as proposals for action, so that the agreements reached by the community or group in question might truly be consensual.

In the MOOC "Information and Communication Technologies in Education" we have seen how a diverse range of channels of communication have been used for different tasks. Moreover, we have seen how, on some occasions, the same tool has served to fulfill distinct functions, in addition to serving for the expression and exchange of ideas; for example: putting together work groups; receiving and offering help among colleagues; implementation of strategies for problem solving; and proposals for follow-up or agroupment of the end products that were created.

Expressed in another way, in this MOOC different levels of communication and integration were reached and these were able to become concretized into effective strategies of collaborative work; a significant achievement, given the characteristics of the massive group, in which there was a confluence of heterogeneous levels of technological abilities, the limitations in terms of wide-band connectivity of many of the participants, and the social functioning (the acceptance and appropriation) that the individuals perform with the dynamics, tools, activities, and materials that were proposed for their utilization. The diversity of the tools selected so that the different users would feel comfortable and the constant invitation to appropriate those tools for themselves, affording a sense of recognition for such practices, were factors that made possible the creation of a learning community in which both communication and group collaboration were exercised.

Data Collection Instruments

To collect data, we resorted to the semi-structured interview, participating observation, secondary content analysis as well as survey. According to the characteristics of the case analyzed and since the activities with the mobile devices were performed outside the institute, we privileged the semi-structured interview as the technique to collect data (Sierra, 1998) and, secondly, the participating observation in the classroom.

The first instrument was the secondary content analysis matrix that we applied to 80 research reports in order to obtain information about the way mobile devices were being used in other higher education institutions, the students and professors' perception, the impact on learning and the theoretical models in effect. The information derived from this analysis was used to locate the orientation of the research, define the case study and plan the design of didactic activities of the course.

The semi-structured interview was applied at mid and end of the semester. The objective was to understand the way the students used mobile devices to perform different activities during the course and the way in which they learned through this type of artifacts.

The participating observation was performed in two sessions per week and per group during fifteen weeks, with an average duration of forty minutes each. In each session, we paid attention to the behavior of the teams in regard to the presentation of the progress of the activities, approach to doubts, comments and observations related to the tasks assigned. We also took into consideration the students' doubts in regard to the mobile devices outside the classroom, their responses to the professor's questions, as well as the use youngsters made of their mobile phone during class. Moreover, we recorded the students' comments regarding the facility or difficulty in finding how to use their *smartphone* to perform the activities assigned by the professor.

The 53 participants self-applied the first survey at the beginning of the semester. The objective was to obtain data on the way the subjects of the study use and perceive the use of *smartphone*s for learning purposes. In regard to the confidentiality of the instrument, the calculation of the Cronbach Alpha coefficient yielded a 0.71 result.

The second survey, with open questions, was applied at the end of the course to all the participants through an online Moodle platform. The object was to carry out a last assessment from the students' perspective in regard to the cognition and learning process that structured the experience of intensive use of mobile devices. The resulting information, as well as in the second part of the semi-structured interview, was used to try to respond to the research question and address the main object of the study.

Data Analysis

The data were analyzed through the linear and axial codification with the support of the Atlas.ti software, with the intention to define categories and their corresponding families. To do so, we generated a hermeneutic unit in Atlas.ti, in which we loaded six primary documents with the transcriptions of the twelve interviews applied to the student teams. Likewise, we added the results of the interviews with open questions applied at the end of the experience. The latter was organized into five documents, at the rate of one per question-answer. Lastly, we added a document with the transcription of the notes of the field log.

Once the categories were obtained, they were grouped into three families following the process of analysis suggested by Atlas.ti. The criterion used to organize these families was the narrow relation they have among them in function of their theme content.

In order to achieve more specific concepts of each of the three families, we developed co-occurrences per code or category of families through the use of the Atlas.ti co-occurrence explorer. From the analysis, we developed a network view of the categories and their relationships.

Study Assessment

To assess the study, we used the credibility, auditability and transferability criteria (Lincoln & Guba, 1985). Since the research was developed throughout a semester and the interviews were conducted at mid and end of the semester, we had the opportunity to corroborate the data obtained in the first phase with informants. Likewise, we used the theoretical triangulation method (Okuda & Gómez-Restrepo, 2005) in order to contrast the results with the cognitive approaches described in the theoretical framework in terms of congruity.

We have a registry of the methodological strategies used and their justification, as well as the actions, difficulties and results. In regard to the

criterion of transferability of the results to other contexts, the homogeneity shown by the groups within the Hermosillo Technological Institute should allow to conduct tests in courses of different fields of study.

RESULTS

The data obtained from the application of the survey to establish a diagnosis of the use and the perception of the mobile devices among students show that 91% of the interviewees used a *smartphone* as access modality to the Internet in and out of school. The interviewees resort to the Internet mainly to access social networks and to communicate with family and friends beside unloading information for academic assignments. The applications mostly used in the last year are those related to the use of social networks: Facebook (82.8%) and WhatsApp (68%).

In regard to the students' perception about the use of the *smartphone* as means of learning and the possibility to use it to learn in school, 95% showed a favorable attitude besides claiming the it facilitated school activities, it is practical and time-saving. Its greatest advantages were its portability and speed of access to information. In regard to its disadvantages, the majority of students pointed out that the distraction factor in the classroom played a very important role.

From the analysis with Atlas.ti, we obtained 22 categories (See Table) which were grouped into three families by following the analysis process suggested in Atlas.ti. The criterion used to organize these families was the narrow relation they have among them in function of their theme content. The resulting families were: learning practices, mobile devices, organization, communication and collaboration.

Table. Main categories according to the frequency of their emergence in the analysis

Category	Code	Frequency
Empirical cognition	CE-E	94
Distributed Knowledge	DC	43
Smartphone as Practical Tool	SHP	39
Collaboration	CO	38
Teacher's Role	RD	34
Communication through Social Networks	CRS	33
Role of the Theory	RT	33

Use of *Smartphone* as Means of Learning	USMA	32
Procedures and Learning Activities	PAA	27
Team Organization	OE	26
Learning the Use of Mobile Technology	AUTM	24
Significant Learning Experience	ESA	21
Tutorial Consultation	CT	17

Empirical Cognition

This category consisted in a total of 94 appointments and obtained the highest score in frequency of emergence in all this study. The concepts emerging from this category are learning through experimentation, interaction, exploration and practical learning.

All the teams interviewed point out that their first reaction in front of the software that would help them accomplish a task was to experience directly with the program. With this purpose in mind, the students are driven by the pedagogical objective of the activity to perform, besides the brief introduction made in class by the teacher on the operation of said software; for example, applying a market survey through the use of an app such as KoBo Collect, implies exploring the application to view the questionnaire previously developed online. If the objective is not attained, the students resort to other members of the group or to video tutorials available on the Internet.

In regard to learning through exploration and experimentation, the interviewees said:

> You feel that you have learned on your own, that you discovered it. You master it. (Participant 13, personal communication, May 20th 2016.)
>
> As if you have discovered something that has already been done and that you are in a tutorial but on your own, you could do it. (Participant 19, personal communication, May 20th 2016.)
>
> Yes, the effort of trying and doing it; if you make a mistake, you can see another option and you could do it and you did it. (Participant 14, personal communication, May 19th 2016.)
>
> Practice makes you remember and allows you to do things. (Participant 3, personal communication, May 18th 2016.)
>
> You learn more easily doing than reading or only listening. (Participant 18, personal communication, May 24th 2016.)

As for the theory, students pointed out that one forgets it. Conversely, learning through *smartphone* "is more practical and one does not forget" (participant 6, personal communication, May 19th 2016). Likewise, they commented that practice facilitates remembering and, hence, performing the activities.

Another reason to prefer this way of learning is that it allows the students to manipulate a symbolic object, such as an app without that action having negative consequences in the sense that the device may fail. The awareness that there is no danger in breaking the Smartphone gives them confidence to explore through the software and observe "what changes and see what is going on", as they claimed.

The fact of experimenting with an app gives them the facility to generate ideas along the way: "We prefer that it be more practical [...] and what occurs to me at the moment" (participant 14, personal communication, May 23rd 2016). The interactivity and interconnectivity of the environment with the communication available on the Internet constitutes a propitious atmosphere for ideas to emerge. If we compare with paper and pencil, the interviewees judge the latter as a static means that awakens the imagination, but does not connect them with a multitude of standpoints from which new ideas arise.

The students claim that they construct the meaning of an activity through the exploration and interaction with the app in terms of object of learning. They also mentioned that they proceed by intuition since ideas arise while exploring and interacting with the software: "I have learned to use them [the apps] by pushing the buttons and experiencing the app since we used every one of them and this way, I learned all the topics and items of the course" (participant 9, personal communication, May 19th 2016). For students, knowledge is generated by practice.

The way empirical cognition operates may be observed in the following excerpt taken from the interview with one of the teams: "The way in which we do it was to insist and insist until things are as they should be, and if you first make a mistake, then, on the second attempt, you know how to solve it" (participant 1, personal communication, May 18th 2016).

The participating observation, on the one hand, is limited to the classroom space since most of the activities with mobile devices are done outside the institution. In the classroom, the *smartphone* was scarcely used except when the need arose to look for some information of a specific topic or recover some data to supplement class information.

The opportunity to observe the students interacting with mobile devices occurred in some occasions during the practices in the computer laboratory. This was the case of the exercises to learn to develop e-commerce stores, labels with QR code or app design. In one of the laboratory sessions, at mid semester, we requested the students to unload

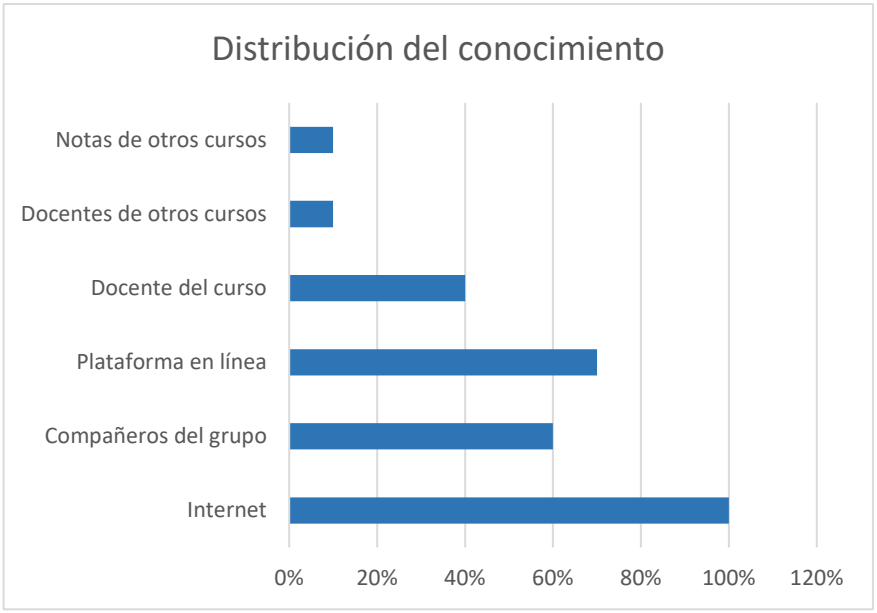
the Droid QR application from the Internet. Next, each team concentrated on the *smartphone* of one of the members of the team and proceeded to manipulate the app without previously consulting a textbook or getting information on how it works.

On another occasion, we observed that the students would introduce the data required in the app with which they were practicing and, next, they would proceed to manipulate it intuitively, by trial and error, in order to attain a result and without having a clear idea of what they expected to find. When one of them achieved performing the activity, he would share it with the others for them to learn. They request the teacher's assistance to finish the task on few occasions.

Distributed Cognition

This category is the second with greater frequency of emergence in the analysis with a total of 43 appointments.

To access the information that allowed them to carry out the different activities of the course, the students resorted to a variety of resources that went from the search on the web, digital libraries, members of a team or the group in general, Moodle platform, notes from previous courses, teachers of this field of studies, as well as people external to the institute (See Graph).



Graph. Distribution of knowledge to which the teams resorted for the course activities.

The teams pointed out that their first option to learn how to perform an activity, after trying to manipulate an app, was to resort to tutorial videos available on YouTube. The latter worked as a guide that helped them in learning the use of software. According to them, they turn to this type of material, since these materials present visually and comprehensibly the steps to follow on how to manipulate a program.

Tutorials are another alternative that contain images and text which are found through Google search. The latter is generally a starting point for any school research. When they do not succeed in understanding a tutorial video, they resort to the members of the group that are most skilled in using an application: "First, we check the material by ourselves. If it is too difficult, then we ask someone who did it; he shows us how he did it, and that's it". (Participant 10, personal communication, May 19th 2016).

CONCLUSIONS

In regard to the question: What are the cognition modalities associated with the use of mobile devices in a university course? The study shows that the latter favored a type of cognition called empirical, while emphasizing a distributed cognition modality. The foregoing leads us to formulate the hypothesis that mobile learning favors an empirical-type cognition based on the execution of procedures. Empirical cognition is understood as a knowledge mode focusing on the search to solve a situation considered problematic, from the data, and experiencing through them a procedure which sequential order oscillates between an algorithmic and heuristic standpoint (Zabala, 1994). This form of knowledge is characterized by privileging a procedural-type mental activity through actions which order is repetitive (algorithmic) or varies in function of the situation to solve (heuristic).

Given its interactivity characteristics, the *smartphone* request form the student an active attitude of exploration and experimentation that contrast with the student's passive listening, that of being a spectator in a classroom. The use of mobile devices in education underlines a form of learning in which the procedure is predominant in the face of demonstration (Serres, 2012). It is a type of enacted cognition in which the student's embodied action generates cognitive structures that allow the student to act on his environment.

The empirical cognition modality linked to the use of mobile devices requires, in turn, to be contrasted with the results obtained by the studies that infer that mobile learning develops higher cognitive skills such as those implied in problem solving, critical or creative thought. In particular, it is important to understand in which way a series of repetitive or heuristic actions, through the use of a mobile device, is associated with the formation of higher cognitive skills.

The results of a second group of researchers quoted in this study, having to do with the use of mobile devices and problem solving, show that higher skills of thought developed by the students are limited and they tend to concentrate on the application aspects more than on critical or creative thought.

The learning practices identified during the study are located, most importantly, in resorting to the empirical-type of learning, social networks as a way of collaborating and accessing knowledge distributed on the network, as well as the members of the group and the teachers. These practices are closely linked since the use of the *smartphone* seems to be linked with a form of cognition based on the direct manipulation of apps, similarly to the use of social networks as a privileged interaction mode by individuals that are located at geographical different times and places.

By considering distributed cognition as a mode to access information and knowledge is fundamental. The student not only learns from the act of manipulating the apps but rather from the fact of looking for information in a diversity of sources as Internet, his own companions, the teacher, experts, etc., as shown in the results of this study.

PERSPECTIVES

The cognition modalities aforementioned underline the need to consider their role in future mobile learning experiences, with the purpose of not limiting the students in performing learning practices based only on forms of reasoning such as induction and deduction, traditionally fostered by textbooks.

More specifically, cognition modalities such as the empirical cognition offer the possibility to open new lines of research in the use of digital means in learning in which alternative ways of reasoning such as abduction (Pierce, 1974) are considered, besides developing new orientations in the field of mobile learning and embodied cognition such as Denham, Quick and Atkinson (2012) proposed which aims at exploring the potential of mobile devices in mastering incarnated or embodied learning.

We still have to explore the viability of a form of cognition such as the empirical cognition and its implications in the learning modes dominated by the book. However, the interest of youngsters in the use of the *smartphone* as learning support is undeniable. On the other hand, new qualitative and quantitative research that helps us explore the hypothesis with which this study concludes, i.e., to evaluate its viability in designing future experiences in the field of mobile learning, is required.

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