

## **Empirical Model for Mobile Learning and their Factors. Case Study: Universities Located in the Urban City of Guadalajara, México**

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### **ABSTRACT**

Information and communication technologies (ICT) are producing new and innovative teaching-learning processes. The research question we focused on is: Which is the empirical model and the factors for mobile learning at universities located within the Metropolitan Zone of Guadalajara, in Jalisco, México? Our research is grounded on a documentary study that chose variables used by specialists in m-learning using Analytic Hierarchy Process (AHP). The factors discovered were three: Technology (TECH); Contents Teaching-Learning Management and Styles (CTLMS); and Professor and Student Role (PSR). We used 13 dimensions and 60 variables. 20 professors and 800 students in social sciences courses participated in the study; they came from 7 universities located in the Urban City of Guadalajara, during 2013-2014 school cycles (24 months). We applied questionnaires and the data were analyzed by structural equations modeling (SEM), using EQS 6.1 software. The results suggest that there are 9/60 variables that have the most influence to improve the interaction with m-Learning model within the universities.

### **Keywords:**

Mobile Learning, Factors, Analytic Hierarchy Process, Universities

### **RESUMEN**

*Las tecnologías de información están produciendo nuevas formas en el proceso de enseñanza-aprendizaje, por lo que nuestra pregunta de investigación es: ¿cuál es el modelo empírico del aprendizaje móvil y sus factores en las universidades localizadas en la zona metropolitana de Guadalajara, México? Así, esta investigación se orienta a responderla y se basa en un estudio documental para seleccionar las variables con especialistas en m-learning mediante el uso del proceso analítico jerárquico. Los factores finales fueron tres: tecnología; contenidos, administración de la enseñanza-aprendizaje y estilos; y rol estudiante-profesor con trece dimensiones y sesenta variables. El estudio fue aplicado en veinte profesores y ochocientos estudiantes de ciencias sociales, pertenecientes a siete universidades localizadas en la zona metropolitana de Guadalajara, México, durante el periodo 2013-2014 (24 meses). Los datos de los cuestionarios fueron analizados por modelización de ecuaciones estructurales, usando el software EQS 6.1. Los resultados finales señalan que son seis de sesenta variables las que tienen mayor influencia para mejorar la interacción con el modelo m-learning en las citadas universidades.*

### **Palabras clave:**

*Aprendizaje móvil, factores, proceso analítico jerárquico.*

### **INTRODUCTION**

The projected growth of education supported by Information and communication technologies (ICT) responds to solve problems of geography, time, and demand. Unfortunately, it also has drawbacks, such as low intensity regarding interactivity between professor-student; feedback tends to be very slow; it presents difficulties to correct materials and assessments errors; students dropout more than with face to face teaching, etc. (Gallego & Martinez, 2002).

E-learning is defined by the Fundación para el Desarrollo de la Función Social de las Comunicaciones (FUNDESCO) as “a system for delivery of distance learning, supported by ICT which combines different pedagogical elements: classical training (classroom or self-study), practice, real-time contact (in person, video or chat), and deferred contacts (tutor, forums discussion, email)”

(Marcelo, 2002). Due to technological advances, we have a growing number of mobile devices: smartphones, notebooks, notepads, iPads, and tablets. According to Forrester Research Portal (2015), a third of tablets sold in 2016 will mostly be used for business purposes (Kaganer et al., 2013). Moreover, the existing institutional frameworks are inadequate to rapidly respond to the challenges of new education technologies (Dussel & Quevedo, 2010).

## PROBLEM AND RATIONALE OF STUDY

Hernández-Sampieri (2010) suggests defining the problem by means of a question, consequently we propose as a research question (RQ) the following: Which is the empirical model and its factors for mobile learning and their factors in universities located at the Metropolitan Zone of Guadalajara? Thus, our general objective (GO) is to establish factors and variables to discover the factors from m-learning as a conceptual empirical model for mobile learning and their factors. We used two specific questions (SQ):

SQ1: Which are the factors, dimensions, and variables that describe the overall conceptual model?

SQ2: Which are the relevant factors, dimensions, and variables within the conceptual model?

Our general hypothesis (GH) is: All the relevant variables have significant positive effect over m-learning, and as arguments we use three hypotheses:

H1. A high level of technologies (TECH) generates a high level of m-learning Contents Teaching-Learning Management (CTLM).

H2. A high level of CTLM generates a high level of m-learning in Professor and Student Role (PSR).

H3. A high level of PSR generates a high level of TECH in m-learning.

## METHODOLOGY

Our study is based on documentary study and analyzed by means of the Analytic Hierarchy Process (AHP) with the help of specialists in m-learning. With our theoretical framework we discovered three main factors: technology (TECH); contents teaching-learning management, and styles (CTLMS); professor-student role (PSR). We identified the variables and dimensions based on the concepts of different m-learning authors. The study was applied on 20 professors and 800 students both participating in social sciences m-learning courses, from 7 universities. We used structural equations modeling (SEM), and EQS 6.1 software to analyze data of the questionnaires, and respond to the RQ and GH to determine additional underlying relationships between the factors' variables.

## THEORETICAL FRAMEWORK

AHP. We documented more than 100 studies of m-learning factors, looking for the most mentioned variables, and using an AHP technique (Saaty, 1997); we asked 5 specialists in m-learning to select the most important variables to use in our conceptual model. See Table 1.

**Table 1.** AHP or Saaty's Theorem Results.

| Objective    | Mobile learning                                     |           |            |
|--------------|---|-----------|------------|
|              | Variable  | Frequency | AHP weight |
| Alternatives | 1 Technology  | 28        | 0.23       |
|              | 2 Contents, Teaching Learning Management and Styles | 16        | 0.22       |
|              | 3 Professor   | 12        | 0.19       |
|              | 4 Student   | 10        | 0.13       |
|              | 5 Innovation  | 9         | 0.07       |
|              | 6 Assessing   | 8         | 0.06       |
|              | 7 Policies  | 7         | 0.04       |
|              | 8 Learning Management                               | 3         | 0.02       |
|              | 9 Web Learning                                      | 4         | 0.01       |
|              | 10 On Line Communities                              | 1         | 0.01       |
|              | 11 Multimedia Learning Objects                      | 1         | 0.01       |
|              | 12 Augmented Reality for Learning                   | 1         | 0.01       |
| TOTAL        |   | 100       | 1.00       |

The factors with their main features under the m-learning vision are:

1. Technology (TECH). To describe this variable, we propose two aspects at the same time: the technical features based on OSI model and the extrinsic/intrinsic characteristics of technology, based

on the equipment features perceived by the user (Shneiderman & Plaisant, 2005). About OSI (ISO/IEC7498 Open System Interconnection, 1994), model developed by the International Organization for Standardization (ISO) in 1980, this framework defines the technical interconnection architectures and communications systems, consisting of seven layers: physical, link, network, transport, session, presentation and application. About the second model, we consider the equipment intrinsic features such as ergonomics, portability, weight, size, design, speed of access to the telecommunications network, processing, storage, capacity of growth of the equipment, and the equipment extrinsic based provider of telecommunications services such as coverage, price, speed of access, availability, compatibility of protocols, among other features (Shneiderman & Plaisant, 2005).

In order to guarantee and achieve the continuity and implementation of m-learning technology, it is necessary to develop institutional policies that provide direction and enough resources, including an assessment system to verify participation, activities and quality of teaching actions and course contents (Garrison & Anderson, 2003).

Topics that a policy document and strategic plan should include are organized as follows (Garrison & Anderson, 2003):

1. Vision: –understand background–define core values–describe strategic goals
2. Needs and risk assessment:–identify issues–identify challenges–identify best practices
3. Educational principles and outcomes described
4. Implementation initiatives and strategy: –link to institutional priorities–create a steering committee–identify communities of practice
5. Infrastructure: –design multimedia classrooms–describe administrative processes
6. Infostructure: –design institutional connectivity–create a knowledge management system–provide digital content–create standards
7. Support services: –provide professional development–provide learner support
8. Budget and resources
9. Research and development framework
10. Benchmarking: –establish success criteria–assess progress–communicate direction and accomplishments
11. Assessing

2. Contents (C). People perceive e-learning as a formal course and not as a tool and an attitude towards lifelong learning. So, there are new features of learning, passing through contents to activities giving to the students new perceptions over the activities, that are more clearly related to the objectives, competencies and skills we seek to achieve (Cabero, 2012) as shown in Table 2.

**Table 2.** Differences between Learning Centered regarding Content and Activities.

| Learning Centered Content  | Learning Centered Activity  |
|--|---|
| The student is usually reactive and passive, waiting for the professor to speak or decide.                                 | Students have an active involvement in their learning, without waiting for the professor to decide for them.            |
| Decision space student is small.   | Wide freedom for students and space for own decisions as important elements of their learning.                          |
| Individual learning is promoted.   | Learning is promoted in collaboration with colleagues; students have opportunities to be independent in their learning. |
| Students do not have many opportunities to learn independently.  | Process-related skills with a focus on results, and the search, selection, and management of information.               |
| Memory replication of content and skills. Personal and professional education often is limited to certain periods of life. | Personal and professional education throughout life.  |

Source: Adapted from Cabero, 2012.

According to Cabero (2012), an important design aspect is that there are several types: ranging from the methodologies and strategies that will be used in the virtual action (training design); the type of navigation that allows within materials (navigation design); the chances of students, professor relationship (interaction design); graphic forms in which present the information (navigation design); different evaluation strategies to be permitted and used in the training (evaluation design), and ways of presenting content with forms of construction (design of content).

2a. Contents Teaching-Learning Management (CTLM): Several theories explain how people learn, and over 50 of them are online; however, most are variations of three main trends: *behaviorism* (behavior), *cognitivism* (mind and brain) and *constructivism* (construction of knowledge). New theories that support m-learning are: *connectivism* (network connections) and *enactivism* (actions based on the body and senses) (Woodill, 2011).

2b. M-learning: Its definition has shifted in recent years due to technological advances. See Table 3.

**Table 3.** M-learning descriptions.

| Author                   | Description  |
|--------------------------|--|
| Brazuelo & Gallego, 2011 | "... The educational model that facilitates the construction of knowledge, problem solving learning and development of skills or different skills autonomously and ubiquitous thanks to the mediation of portable mobile devices." |
| Traxler & Kukulska, 2005 | "... Any educational process where the only dominant and prevailing technology is provided by equipment type: handheld or palmtop..."  |
| Keegan, 2005             | "..... Mobile Learning should be restricted to learning on devices which (...) [anyone] can carry in his pocket."  |
| O'Malley et al., 2005    | "... Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies."        |

Source: Brazuelo & Gallego (2011); Traxler & Kukulska (2005); Keegan (2005); O'Malley et al. (2005).

Consultant or professor tells students what to do in their learning; in other words, they become *facilitators* that make the student achieve higher levels of knowledge (Woodwill, 2011).

3. Professor (P). The concept of Vygotsky (Moll, 1993) having greater recognition and applicability in the educational field is the zone of proximal development (ZPD). This concept means: "The individual's actions that he can perform successfully start only in interaction with others, in communication with them and with their help, but can then play in totally autonomous and voluntarily" (Matos, 1995). They are responsible for designing strategies that promote intensive interaction according to ZPD, considering students' previous level of knowledge, from the culture and the meanings they have in relation to what they will learn (Onrubia, 1998). The process is established where a group of professors together design, teach, observe, analyze, and review one class lesson. See Table 4.

**Table 4.** Professor Requirements.

| Indicators           | Example/Description   | Comments   | Source                              |
|----------------------|---|--|-------------------------------------|
| Informatics Culture  | Permanent update of information by using of technology.                     | Attitude and intuitive ability to learn the use of technological resources.  | Ng & Nicholas (2013); Cabero (2012) |
| Lecture Cycle        | Group planning/experimental lecture/individual reflection/group reflection. | Teaching based on enactment.   |                                     |
| Cognitive Objectives | Bloom's digital taxonomy.   | Association with the enactive cognitive objectives, such as teaching, knowledge, comprehension, application, analysis-synthesis, and evaluation. | Bloom (2012)                        |

Source: Ng & Nicholas (2013); Cabero (2012); Bloom (2012).

3a. Student (S): This topic takes into account the cognitive, memory, prior knowledge, emotions, and possible motivations. The student will assume the commitment with his own learning process and will find out, in the self-evaluation, the key to discover his own progress to make choices (Montoya, 2008). See Table 5.

**Table 5.** Variable: Student Requirements.

| Variable           | Example/Description   | Comments  | Source                        |
|--------------------|---|---|-------------------------------|
| Previous Knowledge | Tacit and explicit knowledge stored in memory with conditions to be applied in the teaching-learning process. | This impacts in how students understand new concepts. | Driscoll (2005); Tirri (2003) |

|                          |   |  |  |
|--------------------------|---|--|--|
| Memory                   | Techniques to successfully encoded with use of signals such as categorization, mnemonic, tactile, auditory, sensory, etc. | It involves how multimedia actively encourages students in their learning.   |  |
| Context and Transference | Static knowledge versus dynamic knowledge   | It involves how to make students use what they learn to strengthen memory, understanding, and transfer the concepts to different contexts. | Carroll & Rosson (2005); Driscoll (2005) |
| Learning by Discovering  | Application procedures and concepts to new situations; case study.  | It involves how to encourage students to develop skills to filter, select, and recognize relevant information in various situations.       | Tirri (2003)                             |
| Emotions and Motivations | Student's feelings to perform a task; reasons for their achievement.  | Student inclination or ability to adopt an attitude that prepares your emotional state or desire to accomplish a task.                     | Carroll & Rosson (2005); Tirri (2003)    |

Source: Carroll & Rosson (2005); Driscoll (2005); Tirri (2003); Carroll & Rosson (2005).

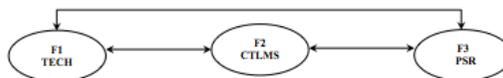
3b. Contents Teaching-Learning Styles (CTLs): It described how students use what they already know, and how the information is encoded, stored, and transferred. It covers theories about knowledge transfer and discovery learning (Carroll & Rosson, 2005). The experience and prior knowledge affect learning as does the atmosphere of the student. So their application is under the *experiential memory* (Driscoll, 2005). Professors teaching style is important. They are, explicitly or implicitly, using observation techniques trying to *know their* students (Gallego & Martínez, 1999), discovering *learning styles*. See Table 6.

**Table 6.** Learning Styles.

| Teaching-Learning Styles | Description   |
|--------------------------|---|
| Activist                 | Students are fully and without prejudice involved in new experiences. They grow to challenges and get bored with long maturities. They are people who engage in the affairs of others and focus around all activities.  |
| Reflexive                | Students learn the new experiences but do not like to be directly involved in them: Collecting data, analyzing them carefully before reaching any conclusions, and enjoying watching the actions of others, listening but not intervene until they have taken over the situation. |
| Theoretical              | Students learn best when they are taught about things that are part of a system, model, concept, or theory. They like to analyze and synthesize. For them, if something is logical, it is good.   |
| Pragmatic                | Students apply and practice their ideas. They tend to be impatient when people who theorize.  |

Source: Adapted from Honey & Mumford (1992).

Figure 1 presents the factors for the proposed model.



Notes: F1. Technology (T); F2. Contents and Learning-Teaching Management (CLTM); F3. Professor Student Role (PSR).

**Figure 1.** General conceptual model for mobile learning and their factors in universities located at the Metropolitan Zone of Guadalajara, México

## RESULTS

It shows the final questionnaire design with 3 factors, 13 dimensions, and 60 independent variables grouped according to what the main authors describe of m-learning.

### **Personal Background**

If you are a STUDENT: -Name of m-learning course; -What is your occupation? Manager/Employee non-technical/Employee technical/Professor or trainer/Student; -How old are you? 24 or younger/25-29/30-40 /41-50 / over 50;

-Gender? Female / Male; -What is your level of education? High school matriculation/One to three years of post-secondary education/Four or more years of post-secondary education; -Personal Digital Assistant (PDA) ownership -Do you own? Smartphone/Lap/Palmtop/Other; - Where did you study the mobile learning course? At home/ At the office or work/ While travelling/ Other.

If you are a PROFESSOR: -Name of the m-learning course;-What kind is your assignment? Social Sciences/ Engineering;

-Are you: Instructor/Assistant Professor/Associate Professor/ Professor;-How old are you? 24 or younger/25-29/30-40/41-50/over 50;-Gender? Female/Male; -What is your level of teaching? High School/ Undergraduate/Postgraduate/;-Personal Digital Assistant (PDA) ownership-Do you own? Smartphone/Lap/Palmtop/Other; -Where did you study the mobile learning course? At home/At the office or work/While travelling/Other.

### **FACTOR 1. TECHNOLOGY (TECH)**

#### **Dimension 1. Technology Friendliness (TFRN)**

Variables (measured by Likert Scale: Strongly agree/ Agree/ Uncertain/ Disagree/ Strongly disagree):

1. I need a special training to use my PDA (Ng & Nicholas, 2013).
2. The screen on the PDA makes it difficult to do my school work (Ng & Nicholas, 2013).
3. Writing with a PDA is easier than writing by hand on paper (Ng & Nicholas, 2013).
4. With a PDA it is easy to take my school work (Ng & Nicholas, 2013).
5. I would recommend mobile learning as a method of study to others (Keegan, 2005).

#### **Dimension 2. Technology-Synchronous Communication (TSYC)**

6. Chat in m-learning is very useful is better than PC (Keegan (2005).
7. IP telephony functions are very well with the m-learning course (Keegan (2005).
8. The sending of SMS is very useful (Ng & Nicholas, 2013).

#### **Dimension 3. Technology Asynchronous Communication (TASY)**

9. Communication and sending assignments for submission with the students (or tutor) by e-mail functioned well. (Keegan, 2005; Ng & Nicholas, 2013).
10. Writing messages to the Forum functioned well (Keegan, 2005).
11. Answering assignments for submission applying the m-learning functioned well. (Keegan, 2005).
12. Accessing to notes and reading text functioned well (Keegan, 2005).

#### **Dimension 4. Technology Multimedia (TMMD)**

13. Accessing to sound, video, and graphical materials functioned well (Keegan, 2005).
14. Activities/assignments involving manipulation of graphical materials functioned well (Keegan, 2005).

#### **Dimension 5. Social Media (TSME)**

15. To learn (or teach), I tend to be in different networks, in permanent interaction and collaboration (Woodill, 2001).
16. To learn (or teach), I tend to participate in gamings, simulations and/or virtual worlds (Woodill, 2001).
17. To learn (or teach), I feel I spend a lot of time connected in different networks with scarce results (Woodill, 2001).

### **FACTOR 2. CONTENTS -TEACHING LEARNING MANAGEMENT AND STYLES (CTLMS)**

#### **Dimension 6. Teaching-Learning Management (CTLM)**

18. Accessing course content was easy (Keegan, 2005).

19. Communication with and feedback from the student (or tutor) in this course was easy (Keegan, 2005).
20. Mobile learning is convenient for communication with other course students (or professor) (Keegan, 2005).
21. PDAs help me learn (or teach) my subjects better (Ng & Nicholas, 2013).
22. There are no disadvantages in using PDAs in the classroom (Ng & Nicholas, 2013).
23. PDAs make learning (or teaching) more interesting (Ng & Nicholas, 2013).
24. PDAs help me organize my time better (Ng & Nicholas, 2013).
25. I feel my learning (or teaching) process is more willing to punishment-reward cycle (Woodill, 2001).
26. I feel my learning (or teaching) process is more willing to the individual internal brain processes such as memory, attitude, motivation, and self-reflection (Woodill, 2001).
27. I feel my learning (or teaching) process is more willing to "learn how to learn" and I select and decide about how they affordable information responds to my needs when I require it (Woodill, 2001).
- V28. I feel my learning (or teaching) process is more willing to the sensation to be connected everywhere, every time to the internet affordances (Woodill, 2001).
- V29. I feel my learning (or teaching) process is more willing to respond to the perception of the environment and my actions, through experiencing, and doing (Woodill, 2001).

#### **Dimension 7. Teaching-Learning Styles (CTLS)**

30. As a student (or professor), I feel that the contents are enough to motivate me to create new forms of knowledge. You are more reflexive (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
31. As a student (or professor), I feel that the contents are enough to motivate me to evaluate the knowledge acquired. You are more reflexive (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
32. As a student (or professor), I feel that the contents are enough to motivate me to analyze knowledge acquired. You are more reflexive (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
33. As a student (or professor), I feel that the contents are enough to motivate me to apply the knowledge acquired. You are more pragmatic (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
34. As a student (or professor), I feel that the contents are enough to motivate me to comprehend the knowledge acquired. You are more reflexive (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
35. As a student (or professor), I feel that the contents are enough to motivate me to memorize the knowledge acquired. You are more pragmatic (Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992).
36. As a student (or professor), I feel the contents are well designed considering: text, context, colors, PDA's formats, accessibility, etc. (Montoya, (2008)

#### **FACTOR 3. PROFESSOR STUDENT ROL (PSR)**

#### **Dimension 8. Professor-Student Perception Feasibility (PSPF)**

37. I am motivated about using a PDA for m-learning, because is easy to use and I learn (or teach) better with it. (Ng & Nicholas, 2013; Driscoll, 2005).
38. When I use a PDA, I am very intuitive using my memory and my senses (Driscoll, 2005).
39. Navigation through the mobile learning course was easy (Keegan, 2015; Moll, 1993; Woodill, 2011).
40. For mobile learning (or teaching) to be effective, it is necessary to use graphics and illustrations (Keegan, 2015).
41. Evaluation and questioning in the m-learning course was effective (Keegan, 2015).
42. The use of PDAs have more advantages than a desktop computer (Ng & Nicholas, 2013).
43. The PDA that I use has a good relation among hardware, software, and connectivity network (ISO/IEC7498; Shneiderman & Plaisant, 2005; Woodill, 2001).

#### **Dimension 9. Professor-Student Perception Value/Cost (PSPVC)**

44. M-learning increases access to education and training. It is still expensive (Keegan, 2005).

45. The cost of accessing the mobile course materials was acceptable (Keegan, 2005).
46. The cost of communicating in the mobile learning course with the tutor and other students was acceptable (Keegan, 2005).

**Dimension 10. Professor-Student Assessing Participation (PSAP)**

47. Effectively encourage others to learn? (Garrison & Anderson, 2003).
48. Contribute regularly at each important stage of the unit? (Garrison & Anderson, 2003).
49. Create a supportive and friendly environment in which to learn? (Garrison & Anderson, 2003).
50. Take the initiative in responding to other students? (Garrison & Anderson, 2003).
51. Seek to include other students in their discussions? (Garrison & Anderson, 2003).
52. Successfully overcome any private barriers to participation? (Garrison & Anderson, 2003).
53. Demonstrate a reflective approach? (Garrison & Anderson, 2003).

**Dimension 11. Professor-Student Assessing Activities (PSAA)**

54. Each of the activities and strategies employed to assess student learning has methodological and epistemological shortcomings (Garrison & Anderson, 2003).
55. All the student products are stored in a database of learning products (Garrison & Anderson, 2003).
56. The assessment is based on using problem-based learning (PBL) activities in m-Learning education (Garrison & Anderson, 2003).

**Dimension 12. Professor-Student Assessing Quality (PSAQ)**

57. As a student (or professor), I evaluate the course objectives, activities, contents; technology affordances are aligned and congruent with the tutoring (or goals) of the course (Garrison & Anderson, 2003).
58. As a student, I evaluate the knowledge acquired versus the initial expectations (If you are a professor: Do you evaluate the knowledge acquired versus the initial expectations of each student? (Garrison & Anderson, 2003; Woodill, 2001).

**Dimension 13. Professor-Student Policies (PSPO)**

59. I'm informed (If I'm a professor: Inform to the students) the security and support policies (Garrison & Anderson, 2003; Woodill, 2001).
60. I'm informed (If I'm a professor: inform to the students) the educational principles and outcomes described (Garrison & Anderson, 2003; Woodill, 2001).

**VALIDITY AND RELIABILITY OF THE MODEL**

Bellow we present a summary of the test and values used in this research. The survey universe was comprised of 20 professors and 800 students both participating in social sciences courses, from seven universities at Metropolitan Zone of Guadalajara (UMZG), México, during the period 2013-2014. And the collection method of data was e-Mail/Inquiry, in scale likert 5, date of fieldwork on January 2013-December 2014. The total e-mail/Inquiry completely answered was 680.

**Ratio NC/VoQ= Number of cases (NC) and variables of questionnaire (VoQ)**

Value and description: NC/VoQ = NC (20 professors + 680 students) (>=100 and <=1000, according Hair et al., 2010) /60 VoQ = 11.66>10 (it is >10 recommended by (Hair et al., 2010).

**CFA (Confirmatory Factorial Analysis ) by maximum likelihood method, and covariance analysis by EQS 6.1 software**

Value and description: To verify the reliability and the validity of the measurement scales. (Bentler, 2005; Brown , 2006; Byrne, 2006).

**Cronbach's Alpha (CHA) and Composite Reliability Index (CRI)**

Value and description: CHA (per factor via SPSS) & CRI>=0.7 / Reliability of the measurement scales (Bagozzi & Yi, 1988; Nunnally & Bernstein, 1994; Hair, et al. 2010).

**Mardia's Normalized Estimate (M)**

Value and description: SB $\chi^2$ . By specifying ME=ML, ROBUST, the output provides a robust chi square statistic ( $\chi^2$ ) called. This is to minimize the outliers and achieve goodness of fit (Satorra & Bentler, 1988).

**Normed Fit Index (NFI)**

Value and description: NFI>=0.8 and <=.89. / Index used for more than two decades by Bentler & Bonett's (1980) as the practical criterion of choice, as evidenced in large part by the current "classic" status of its original paper (Bentler, 1992, and Bentler & Bonett, 1987, cited by Byrne, 2006). However, NFI has shown a tendency to underestimate fit in small samples (Bentler & Bonnet, 1980; Byrne, 2006).

**Comparative Fit Index (CFI)**

Value and description: CFI  $\geq 0.8$  and  $\leq 0.89$ . Bentler (1990, cited by Byrne, 2006) revised the NFI to consider sample size and proposed the Comparative Fit Index (CFI). Values for both the NFI and CFI range from zero to 1.00 are derived from comparison between the hypothesized and independence models, as described previously. As such, each provides a measure of complete covariation in the data. Although a value  $> .90$  was originally considered representative of a well-fitting model (see Bentler, 1992, cited by Byrne, 2006); a revised cutoff value close to 0.95 has been advised (Hu & Bentler, 1999, cited by Byrne, 2006). Although both indexes of fit are reported in the EQS output, Bentler (1990, cited by Byrne, 2006) suggested that the CFI should be the index of choice. (Bentler & Bonnet, 1980; Byrne, 2006).

#### **Non-Normed Fit Index (NNFI)**

Value and description: NNFI  $\geq 0.8$  and  $\leq 0.89$ . It is a variant of the NFI that takes model complexity into account. Values for the NNFI can exceed those reported for the NFI and can also fall outside the zero to 1.00 range (Byrne, 2006).

#### **Root Mean Square Error of Approximation (RMSEA)**

Value and description: RMSEA  $\geq 0.05$  and  $\leq 0.08$ . The RMSEA considers the error of approximation in the population and asks the question "How well would the model, with unknown but optimally chosen parameter values, fit the population covariance matrix if it were available?" (Browne & Cudeck, 1993, pp. 137-138, cited by Byrne, 2006). This discrepancy, as measured by the RMSEA, is expressed per degree of freedom, thus making it sensitive to the number of estimated parameters in the model (i.e., the complexity of the model). Values less than .05 indicate good fit, and values as high as .08 represent reasonable errors of approximation in the population (Browne & Cudeck, 1993, cited by Byrne, 2006). Addressing Steiger's (1990, cited by Byrne, 2006) call for the use of confidence intervals to assess the precision of RMSEA estimates, EQS reports a 90% interval around the RMSEA value. In contrast to point estimates of model fit (which do not reflect the imprecision of the estimate), confidence intervals can yield this information, thereby providing the researcher with more assistance in the evaluation of model fit (Hair et al. 2010; Byrne, 2006; Chau, 1997; Heck, 1998).

#### **Convergent Validity (CV)**

Value and description: All items of the related factors are significant ( $p < 0.01$ ); the size of all standardized factorial loads are exceeding 0.60 (Bagozzi & Yi, 1988), the extent to which different assessment methods concur in their measurement of the same trait (i.e., construct) —ideally, these values should be moderately high (Byrne, 2006).

#### **Variance Extracted Index (VEI)**

Value and description: VEI  $> 0.50$  / In all paired factors as constructs. In a matrix representation, the diagonal represents the (VEI), while above the diagonal part presents the variance (the correlation squared); below the diagonal is an estimate of the correlation of factors with a confidence interval of 95%. See the Table 8 *Discriminant validity of the theoretical model* mentioned below (Fornell & Larcker, 1981).

#### **Discriminant Validity (DV)**

Value and description: DV/It is the extent to which independent assessment methods diverge in their measurement of different traits —ideally, these values should demonstrate minimal convergence (Byrne, 2006). DV is provided in two forms: First, with a 95% interval of reliability, none of the individual elements of the latent factors correlation matrix contains 1.0 (Anderson & Gerbing, 1988). Second, VEI between the each pair of factors is higher than its corresponding VEI (Fornell & Larcker, 1981). Therefore, based on these criteria, different measurements made on the scale show enough evidence of reliability, CV and DV. See the Table 8. *Discriminant validity of the theoretical model* mentioned below. (Byrne, 2006; Anderson & Gerbing, 1988; Fornell & Larcker, 1981).

#### **Nomological Validity (NV)**

Value and description: It is tested using the chi square, through which the theoretical model was compared with the adjusted model. The results indicate that no significant differences are good theoretical model in explaining the observed relationships between latent constructs. (Anderson & Gerbing, 1988; Hatcher, 1994).

## **DISCUSSION**

The CFA results are presented in Table 7 and suggests that the model provides a good fit of the data ( $S-BX^2 = 335.879$ ;  $df = 180$ ;  $p = 0.0004$ ;  $NFI = 0.909$ ;  $NNFI = 0.905$ ;  $CFI = 0.933$ ;  $RMSEA = 0.052$ ). According Table 7, as evidence of the *convergent validity*, the CFA indicates that all items of the related factors are significant ( $p < 0.001$ ) and the magnitude of all the factorial loads are exceeding 0.60 (Bagozzi & Yi, 1988). All the values of the scale exceeded the value recommended 0.70 for the Cronbach's Alpha and CRI, which provides evidence of reliability and justifies the internal reliability of the scale of the business competitiveness ( $\geq 0.70$ ), recommended by Nunnally & Bernestain (1994) and Hair et al. (2010), and the Variance Extracted Index VEI ( $\geq 0.5$ ) was calculated for each pair of constructs, resulting in an VEI more than 0.50 (Fornell & Larcker, 1981).

**Table 7.** Internal consistency and convergent validity of the theoretical model.

| Factor   | Variable | Factorial Load | Robust t-Value | Loading Average | Cronbach's Alpha (>=0.7 per Factor via SPSS) | CRI >=0.7 | VEI >=0.5 |
|--|----------|----------------|----------------|-----------------|--|-----------|-----------|
| F1<br>TECH   | 13       | 0.890***       | 1.000a         | 0.912           | 0.865  | 0.750     | 0.5       |
|  | 15       | 0.923***       | 5.720          |                 |  |           |           |
|  | 17       | 0.924***       | 8.543          |                 |  |           |           |
| F2<br>CTLMS  | 27       | 0.923***       | 1.000a         | 0.914           | 0.823  | 0.751     | 0.502     |
|  | 30       | 0.890***       | 19.350         |                 |  |           |           |
|  | 35       | 0.930***       | 17.560         |                 |  |           |           |
| F3<br>PSR  | 37       | 0.956***       | 1.000a         | 0.915           | 0.790  | 0.753     | 0.506     |
|  | 40       | 0.899***       | 21.453         |                 |  |           |           |
|  | 44       | 0.841***       | 17.312         |                 |  |           |           |
| S-BX <sup>2</sup> = 335.879; df = 180; p = 0.0004; NFI = 0.909; NNFI = 0.905; CFI = 0.933; RMSEA = 0.052<br>a.- Parameters constrained to the value in the identification process.<br>***= p < 0.001 |          |                |                |                 |  |           |           |

According to the Table 7, with the evidence of the convergent validity, discriminant measure is provided in two forms as we can see in Table 8. *First*, with a 95% interval of reliability, none of the individual elements of the latent factors correlation matrix contains 1.0 (Anderson & Gerbing, 1988). *Second*, extracted variance between the two constructs is greater than its corresponding VEI (Fornell & Larcker, 1981). Based on these criteria, we can conclude that the different measurements with the model show enough evidence of discriminant validity and reliability.

**Table 8.** Discriminant validity of the theoretical model.

| Factors                          | TECH         | CTLMS        | PSR   | CHI Square Differences Test (Values <VEI) |
|----------------------------------|--------------|--------------|-------|---|
| TECH                             | 0.5          | 0.462        | 0.336 |   |
| CTLMS                            | 0.270, 0.410 | 0.502        | 0.487 |   |
| PSR                              | 0.323, 0.581 | 0.496, 0.758 | 0.506 |   |
| Interval Confidence Test (<1.0 ) |              |              |       |   |

Note: The diagonal represents the Variance Extracted Index (VEI), while above the diagonal part presents the variance (the correlation squared); below the diagonal is an estimate of the correlation of factors with a confidence interval of 95%.

To obtain the statistical results of the research hypotheses, we applied the SEM as a quantitative method with the same variables to check the *structure model* and to obtain the results that would allow the hypotheses posed, using the software EQS 6.1 (Bentler, 2005; Brown, 2006; Byrne, 2006). Furthermore, the *nomological validity* of the theoretical model was tested using the chi square and through which the theoretical model was compared with the adjusted model. The results indicate that no significant differences in the theoretical model are good in explaining the observed relationships between latent constructs (Anderson & Gerbing, 1988; Hatcher, 1994). Taking in account only the factors described and using again EQS 6.1, we obtained the Table 9 to demonstrate our hypotheses.

**Table 9.** Results of hypothesis testing the theoretical model.

| Hypotheses   | Structural Relation                           | Standardized Coefficient | t Value |
|--|---|--------------------------|---------|
| H1. A high level of TECH generates a high level CTLMS of m-learning model at the UMZG.                                   | TECH -> CTLMS of m-learning model at the UMZG | 0.710***                 | 19.631  |
| H2. A high level of CTLMS generates a high level of PSR in m-learning model at the UMZG                                  | CTLMS -> PSR of m-learning model at the UMZG  | 0.856***                 | 27.600  |
| H3. A high level of PSR generates a high level of TECH in m-learning model at the UMZG                                   | PSR -> TECH of m-learning model at the UMZG   | 0.890***                 | 38.853  |
| S-BX <sup>2</sup> = 182.655; df = 104; p = 0.0005; NFI = 0.931; NNFI = 0.901; CFI = 0.923; RMSEA = 0.065***<br>p < 0.001 |   |                          |         |

The hypotheses results obtained after applying the SEM method are showed in Table 10.

**Table 10.** Hypotheses results.

| Hypotheses | Description  |
|------------|--|
| H1         | ( $\beta = 0.710$ , $p < 0.001$ ), the relationship between TECH and CTLM in m-learning model has significant positive effect. |

|    |  |
|----|--|
| H2 | ( $\beta = 0.856, p < 0.001$ ), the relationship between CTLM and PSR in m-learning model has significant positive effect. |
| H3 | ( $\beta = 0.890, p < 0.001$ ), the relationship between PSR and TECH in m-learning model has significant positive effect. |

Summarizing, we can conclude that all the variables involved are positive and significant over the empirical m-learning model.

However, how the latent variables are interacting? To answer this, the results of SEM as a quantitative technique show how the underlying variables are interacting amongst them at the same time of multiple regressions are in progress. We found 9/60 independent variables as most important on m-learning indicators, to reinforce the model. In order to get it, we have:

F1. TECH: Technology. This factor representing a great opportunity to the Universities at Metropolitan Zone of Guadalajara (UMZG) to increase the positive effect of m-learning empirical model for students and professors because we have to get better technologies and friendliest around multimedia (TMMD) issues, in other words: *accessing to sound, video and graphical materials must work, pretty well* (V13. Keegan, 2005). The social media (TSME) is already present and with a great potential for analyze the benefits on learning, when the student or professor perceives: *To learn (or teach), I tend to be in different networks, in permanent interaction and collaboration* (V15. Woodill, 2001). Hence it is very important, to minimize the sensation of: *To learn (or teach), I feel I spend a lot of time connected in different networks with scarce results* (V17. Woodill, 2001).

F2. CTLMs: Contents, Teaching-Learning Management and Styles

This factor reveals m-learning potential to the UMZG through the Teaching-Learning Management (CTLM) when the student or professor perceives: *I feel my learning (or teaching) process is more willing to "learn how to learn" and I select and decide about how they affordable information responds to my needs when I require it* (V27. Woodill, 2001); the teaching-learning process becomes more reflexive: *As a student (or professor), I feel that the contents are enough to motivate me to: create new forms of knowledge. You are more reflexive* (V30. Cabero, 2012; Bloom, 2009; Gallego & Martínez, 1999; Honey & Mumford, 1992). To more pragmatic: *As a student (or professor) I feel that the contents are enough to motivate me to: memorize the knowledge acquired. You are more pragmatic* (V35. Cabero, 2012; Bloom, 2009; Carrol & Rosson, 2005; Gallego & Martínez, 1999; Honey & Mumford, 1992). Both states of knowledge are very pretty significant in the teaching-learning process.

F3. PSR: Professor-Student Rol. Professor-Student Perception Feasibility (PSPF) must increase the future contents and design devices around the intuitive senses, when both: student and/or professor perceive: *I am motivated about using a PDA for m-learning, because is easy to use and I learn (or teach) better with it.* (V37. Ng & Nicholas, 2013; Driscoll, 2005) and *be effective it is necessary to use graphics and illustrations* (V40. Keegan, 2005). Enactive education processes have a great chance to be explored and implemented here (Woodill, 2001). Unfortunately, about the *cost/value perception* where *m-learning increases access to education and training It is still expensive* in México (V44. Keegan, 2005). We have to expect the rate of prices to broadband access be lower in the near future for the UMZG.

## CONCLUSIONS

We confirmed finally that there are three mean factors: TECH, CTLMs, PSR involved into the m-learning process, with 13 dimensions and 60 variables as indicators. So, we solved the SQ1:

*Which are the factors, dimensions, and variables describing the general conceptual model?* Based on the results of Table 1, Figure 1, and Table 5, presented as a main questionnaire, we proposed the theoretical framework. On the other hand, using SEM, we obtained of the final questionnaire design to solve SQ2: *Which are the most relevant factor, dimensions, and variables in the conceptual model?* These variables are:

-Factor: TECH; Dimension 4.-Technology Multimedia (TMMD); Variable 13.-*Accessing to sound, video and graphical materials functioned well.*

-Factor: TECH; Dimension 5.-Social Media (TSME); Variable 15.- *To learn (or teach), I tend to be in different networks, in permanent interaction and collaboration.*

-Factor: TECH; Dimension 5.-Social Media (TSME); Variable 17.-*To learn (or teach), I feel I spend a lot of time connected in different networks with scarce results.*

-Factor: CTLMs; Dimension 6.-Teaching-Learning Management (CTLM); Variable 27.-*I feel my learning (or teaching) process is more willing to "learn how to learn" and I select and decide about how they affordable information responds to my needs when I require it.*

-Factor: CTLMs; Dimension 7.-Teaching-Learning Styles (CTLS); Variable 30.- *As a student (or professor), I feel that the contents are enough to motivate me to: create new forms of knowledge. You are more reflexive.*

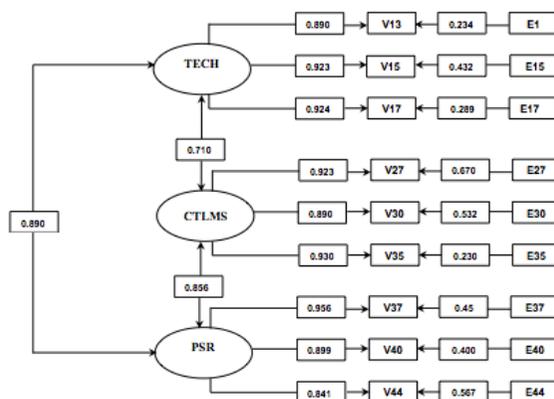
-Factor: CTLMs; Dimension 7.-Teaching-Learning Styles (CTLS); Variable 35.- *As a student (or professor) I feel that the contents are enough to motivate me to memorize the knowledge acquired. You are more pragmatic.*

-Factor: PSR; Dimension 8.-Professor-Student Perception Feasibility (PSPF); Variable 37.- *I am motivated about using a PDA for m-learning, because is easy to use and I learn (or teach) better with it.*

-Factor: PSR; Dimension 8.-Professor-Student Perception Feasibility (PSPF); Variable 40.- *For*

mobile learning (or teaching) to be effective it is necessary to use graphics and illustrations.  
 -Factor: PSR; Dimension 9.-Professor-Student Perception Value/Cost (PSPVC); Variable 44.-  
 M-learning increases access to education and training. It is still expensive.  
 The hypotheses all the relevant variables have significant positive effect to the Mobile Learning model was proved, based on the results obtained in tables 7 and 8. In fact, H3: A high level of PSR generates a high level of TECH in m-learning model at the UMZG shows the most relevant latent factor. So, we solved the RQ at 100%.

The final SEM is showed in Figure 2.



**Figure 2.** Hypothesized model of first-order factorial structure for empirical model for mobile learning and their factors. Case study: Universities located at Metropolitan Zone of Guadalajara, México.

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