





# Learning Analytics in M-learning: Periodontic Education

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**Abstract.** This study aims to understand the transformation of educational and training systems from the perspective of the ubiquitous learning experience of medical and dental students in the period 2019 and 2020 A. The configuration of the learning environment integrates digital ecosystems, monitoring of the actual temporal experience that guides learning outcomes. The training of dental students (clinical periodontology), motivated the design and implementation of teaching strategies with interactive and collaborative activities, which can be carried out in real time with intelligent learning systems; which requires new forms of learning and teaching, with mobile applications that make collaboration networks possible. The development of a didactic sequence that supports collaborative learning with the use of the application, improves the meta-cognitive knowledge of medical and dental students. The analysis plan was carried out with the SPSS 21 software, the T Students test, Crombach alpha test, levene test. The complementary research methodology, the design is descriptive transectional or transversal; the technological mediation is the mHealth application. The results obtained, in real time (data 16 weeks) reveal that the application was used in its entirety 574 h and 19 min, showing a great interest in the developing collaborative learning.

**Keywords:** Liquid generation · Learning analytics · Ubiquitous learning

## 1 Introduction

Higher education in today's learning society is no stranger to the various ups and downs that have shaped the evolution of technological mediations, and through this evolution of humanity, determining needs are being generated; actions are being promoted or decisions justified that extend, limit or question the function and purposes of higher education, both from the diachronic point of view and at a given historical moment [1]. The place of cyberculture changes when technological mediation goes from being merely instrumental to becoming structural; Technology today refers, not to the novelty of devices, but to new forms of multisite thinking, modes of perception and language, new sensibilities and writing, to transformations of culture that involve the educative association that turns knowledge into a direct productive force. In this context, the need arises to confront the unique thinking that legitimizes the idea that current technology

transforms societies. These revolutions draw new coordinates in all areas of human activity that particularly impact the institutions that deal with the training of students in biomedical sciences - (clinical dental specialties) to facilitate their insertion in a changing, technologically complex and highly competitive world in which it is necessary to know and speak new discourses in order not to suffer the exclusion gaps that have emerged or have been consolidated in the heterogeneous and unequal society

Any look highlights the realities of the university that going through multiple problems, involves evaluating its system of operation and governance, reconsidering its structure, reviewing its contributions, identifying the expectations that the achievements and learning experiences in the current generation T (tactile) of our students. In short, revealing the features that are part of the current academic scenarios make university a bastion of culture, knowledge and science; despite the successive questions it has received and the profound challenges it faces; perhaps more than ever, they set in motion its principles, processes and results.

This article reveals how technological mediation in learning is generated, from a trans and interdisciplinary perspective, by establishing relations between knowledge. Learning is vitalized by interaction as a generator of knowledge through the promotion of study networks. However, this problem usually opens the spectrum of the fourth technological revolution, which has undoubtedly contributed significantly to today's society, education, health, and business around the world.

## 2 Related Work

The expansion of the use of information and communication technologies, in particular the internet and more recently web 2.0 applications, has promoted an unusual circulation of information, which is also created and shared autonomously and openly, generating a leading role and providing the means for consumers or producers, to transit, express their positions and confront their imposition of hegemonic thinking and behavior. Therefore, revolutions draw new coordinates in all spheres of human activity that particularly impact on institutions, especially those that deal with the education and training of citizens to facilitate their insertion in a changing, technologically complex and highly competitive world, in which it is necessary to know and manage the new discourses to minimize the exclusion gap that has emerged or has been consolidated in a heterogeneous and unequal society. Although some authors tend to review the literature in the theoretical categories (Table 1), we agree that to carry out the search chains when considering the methodological design of the research.

### 2.1 Learn Connected

Castell [2] indicates in the prologue of his trilogy on the information society [3], that our current society is organized through networks (interconnected nodes), which disrupts a change in our social morphology. These nodes interact with each other, generate new structures, exchange information, and determine a dynamic and flexible social structure, which is constantly moving and, therefore, constantly changing. Analyses of the past are less and less useful in explaining how we are, what we do, how we learn, how our

**Table 1.** Methodological phases with the application and methodological design

Phase I: Preprocessing	Phase II: Process	Phase III: Post process
Planning	Didactic sequence (student)	Formative assessment
Didactic sequence	Intergroup cooperation	Closing of activities
ADDI model	Monitor interface	Peer dialogue
Execution of activities	Feedback	Learning outcome (Rubrics)
Thread diagram: App and design of augmented reality Feedback Tracking student		
	Student discussion	

institutions are organized and what purpose they serve. Change, although not always easily accepted, is the thread of a way of life that finds in the interaction between nodes the models of analysis and development of our society.

The technological system centred on ICT has allowed the emergence of a new economy, a new form of management, a new media system, a new culture and new forms of organization and political and administrative participation. It is Siemens [4] that first suggested that, although until recently behaviorism, cognitivism and constructivism were the main theories that tried to respond to how learning take place, the social change resulting from globalization and the information and knowledge society makes these theories insufficient.

Connectivism in Siemens' words is based on the following principles: a. learning is a process of connecting nodes or sources of information, b. learning can reside in non-human devices. c. power and maintenance of connections is necessary to facilitate continuous learning.

Learning can take place in different environments, so "describes learning as a process of creating a personal knowledge network, an idea consistent with the way people teach and learn on the web [5].

Siemens [6] goes on to indicate that learning is related to creation of connections between information nodes and patterns recognition. Nodes are external entities that can be used to form a network. As Garcia Aretio [7] points out, the good thing about any learning is to be able to dispose, the ability to know how to locate the sources where we are and connect with them is nowadays a vital skill.

## 2.2 Collaborative Learning: A Look from the Research Experience

The most important contribution from the perspective of the research process in the field of M-teaching and learning is based on experience, as part of the context of building a Smilearning application. This constitutes a pedagogical tool, from the subject of oral pathological anatomy, and therefore is the first characteristic that structures an educational epistemology, that is, a new educational knowledge, related to the design and

structuring of a didactic sequence, as part of the context of teaching the specialization in periodontology.

The design of the didactic sequence includes opening, development and closing activities. Each of these activities received input from different active sub-themes such as students, teachers and external experts, who entered, interrogated and interacted to solve the different cases of clinical problems, with different themes within the application. This generated an integrative, interdisciplinary and transdisciplinary knowledge, with theoretical and practical components that generated motivations, feedback, personalization and internalization of the contents in the students, making them accessible at any time, that is, it breaks with temporal synchrony and becomes a ubiquitous type of learning.

The analysis and structuring of the design of the Smilearning application design is a complex and interdisciplinary teamwork process that requires the development in the Ionic language and the ideation of the programming sequence by system engineers, graphic designers and experts in specific topics in the development of applications, who have the contributions and knowledge of the discipline in periodontology and dentistry. To achieve this, it was necessary to monitor in real time, the learning activities of students, this is an activity that escapes the observation and human monitoring, so it requires the use of artificial intelligence for future studies.

From this perspective of ubiquity, the monitoring of students allows us to conclude that the time of use and interaction generates a habit or strategy of using multiple channels, that is, when students enter the application they need and are eager for more information. through various channels, with a tendency to look for different ways, to obtain the information they want, assuming multiple simultaneous tasks. In this sense, we can state that information and communication technologies promote this type of contact with learning content in order to make it meaningful or situated.

The present research puts in special emphasis on the fact that students had up to three computers to connect, such as: cell phones, tablets, among others, with multiple records, that is, they downloaded the application to several computers, in order to achieve the greatest possible multi-situation or ubiquity, this generated a greater appropriation and fostered competitiveness, generated by the reliefs and stimuli they received in each lesson as a prize and qualification, this is not a bias, but reflects the dependence of human beings on technologies and also the conditioned learning that is very useful for these non-contact strategies.

### **2.3 Learning Environments and Their Mediations**

Mediation applied in the educational field is valid as long as the student appropriates its content and puts it into practice in the classroom; educational mediation should have an impact in such a way that the individual is able to solve problems in different disciplinary fields. It is important to emphasize that the teaching-learning processes, the types of scaffolding implemented in an educational mediation must be taken as means and as ends in the teaching processes generated in the different practice scenarios. All educational practice must be accompanied by a wide knowledge of the theory of mediation on the part of the teacher, it must be supported by elements that promote the emotionality of the students, so that the external representations used in their independent work were a

fundamental artefact Due to the curiosity that I generate, the versatility in its use, the application of the concepts to the environment, fundamental aspects in the success of the teaching task.

In the documentary review carried out on pedagogical mediation, it is important to mention the research carried out by Renne Rickenmann (University of Geneva, Switzerland) “The role of the cultural artefact in the structure and management of the teaching-learning sequences”, where some elements that constitute the didactics in education sciences and their use in effective learning practices are addressed. the applications as instrumental mediation in the development of the topic of oral journalism through a categorization of its structure with models of augmented reality are basic elements in the disruptive trends of journalistic practices of the three-dimensional relationship of space.

#### **2.4 Virtual Learning Environments PLE (Personal Learning Environments)**

The concept of PLE (personal learning environment) is defined, from a pedagogical perspective, as the set of all the tools, materials and human resources that a person knows and uses to learn throughout his/her life [1]. Among the functions taken into account in this work, indicated by [2], are: information management (related to personal knowledge management), content creation and connection with others (what is known as learning or personal network knowledge).

The PLE makes the student, either alone or in collaboration with others, gradually and procedurally build their own digital spaces in which they integrate those resources, portals, websites, tools, applications or networks that are usually used to learn-communicate or perform some training activity both formal and informal. This powerful concept is linked to an e-portfolio (electronic portfolio) understood as a kind of compilation or repository of the subject’s own digital productions, such as: his multimedia presentations, his essays, his videos, his concept maps, among others.

Collaboration as a learning strategy is based on working in groups of several people but with similar levels of knowledge to achieve common objectives and carry out activities together, with a positive interdependence between them [3]. In collaborative activities there is not only one right answer, but different ways to reach the result, and for that, students must share and come to agreements, which helps them to be more autonomous and socially and intellectually. The information must be fed back and stimulated by the student; furthermore, you must have a self-regulation of knowledge, you must learn to learn, hence the key for the student to really learn with these new learning methodologies.

### **3 Research Design**

The methodological design is mixed or complementary; the type of research is non-experimental, transactional or transversal (descriptive). Table 1, presents the planning activities of the methodological design.

### 3.1 Techniques and Instruments for Information Gathering

In this research, the instruments used to collect the information were: technique: real-time, the instrument (Smilernig app - phase 2 designs augmented reality in oral periodontics and special pathology, pre-concept, pre-test and post-test questionnaire technique and the instrument is the mobile application (Available on hybrid mobile and web platforms with software registration, Ministry of the Interior, number 13-79-326, May 28, 2020, Colombia.

### 3.2 Population and Sample

For the purposes of this study, the population and the sample were established as follows: following the qualitative approach of the research, the study group was formed by a purposive or convenience sampling procedure. The target population is heterogeneous and consists of the academic program specialized in periodontology. The sample was composed of students enrolled between semesters 4 and 6.

Convenience or intentional sampling, through this method, the researcher is in charge of choosing the subjects that will be part of the sample according to his/her criteria or scope. The participants were selected based on the following criteria: they must be graduate students of journalism who are taking the subject of oral journalism. The total was: 10 medical students from Universidad Unicauca; and 28 residents of the postgraduate course in periodontology at Universidad USC, Cali in the period 2019-2020 A.

The present research, in the methodological design is phase II, and the publication of phase I was published last year in witcom 2019 [4], of which I am the main author.

### 3.3 Consent to Participate in the Study

In accordance with internationally accepted standards to ensure the ethical treatment of persons participating in scientific research, an informed consent form was developed, explaining to the persons participating in the study, its purpose, possible benefits as well as their right not to participate or to discontinue their participation at any time, without prejudice to the study. The investigator provided each person with a copy of this document, which was signed by both the participant and the investigator.

## 4 Experimental Design and Interpretation of Statistical Tests

By conducting an analysis of the impact generated in students of IV and VI semester of the subject of periodontology, a class of strategies and instruments was proposed to evaluate the progress of the participants from the beginning to the end of the course. Subsequently, the data collected was stored and statistically analyzed to verify the significant improvement in the knowledge obtained and the collaborative learning developed, through the program SPSS version 21, Excel, Power point, M-Learning Smilernig, Google Form and Visual Studio code, using the necessary techniques in each program.

Two tests were used in the knowledge test: pre-test and post-test to evaluate the knowledge obtained through the didactic sequence.

Pre-test: after carrying out the activities with the students, a test was made with the Google Form tool to evaluate the knowledge of the students through an element called “assessments rubrics” that corresponds to a series of multiple answers questions where each option has a score indicates: the best answer (5 points), the regular answer (3 points) and the incorrect answer (1 point).

Post-test: after carrying out the corresponding activities with the selected population and the participation in the proposed forums, a test was carried out through the Google form tool with which the knowledge is evaluated through a score in the evaluation headings, in order to demonstrate the knowledge obtained through the Smilearning application.

#### **4.1 Validation of the Instrument**

Validation of the data in the SPSS program with Crombach’s alpha was necessary to verify how reliable the data are for conducting any study. Oviedo and Campo (2005) recommend that the alpha coefficient should be between 0.7 and 0.9 to be accepted.

In this statistic the error is associated to the calculation of the parameters to all the statistical tests (they must have a degree of error and a degree of reliability), the degree of reliability is expected to be above 90%, the error obtained in the normality test of the alpha Crombach have an error of 5%, are not associated to the sampling that was made, it is associated to the applied tests.

The group is so small that, if applied to these groups separately, the results would not be significant, and the teacher is the same. An initial test was applied, to find out their knowledge about the subject of APB topic and then contrast it with the learning obtained through the designed App resource. The design of the research is non-experimental, transactional or transversal.

In the present investigation cronbach’s alpha was, 7 acceptable

#### **4.2 Processes for Data Analysis**

The methodology used is complementary (quantitative and qualitative), and the analysis of the data obtained was carried out according to their nature (Gibbs, 2012). For the processing and analysis of the quantitative data, the statistical software SPSS (Statistical Package for the Social Science), version 21 for Windows, was used. As recommended by several authors such as López Morán (2016), the first thing that was done was descriptive statistics, including frequencies, calculation of central tendency measures (mean) and dispersion (standard deviation). Group differences were analyzed (normalization, student’s t-test for independent samples and analysis unidirectional variance) and the degree of association or relationship between the variables (Pearson’s correlation coefficient and chi-square tests).

The preparation of the quantitative data includes:

- Preparation of the students at the beginning of the didactic sequence, obtaining the previous results with the participants.
- Planning of the proposed activities with the programmatic content of the periodontology subject.

- Use of the Smilearning application, when assigning events and tasks of thematic development.
- Measurement of the times used by students during the 16 weeks of classes in the first period of 2019.
- Orientation of the students in dental cases to perform a theoretical-practical evaluation of the knowledge generating collaborative learning.
- Carrying out the corresponding evaluation to assess the knowledge obtained at the end of the teaching sequence.

## 5 Analysis of Quantitative Data

### 5.1 Interpretation of Results

During the research process, the use and performance of the application was analyzed with the students of the first academic period 2019 B-2020 A; taking the data collected by the TIMONEL platform that allows the analysis of certain characteristics of the students: academic grades, academic history, enrollment, registration. In the development of this research project, two groups of four people were voluntarily selected (four from group A and four from group B) who were studying the “Specialization in Periodontology “ and who were studying the subject “Oral pathology” using the M-Health Smilearning tool. In addition, information was collected by means of a knowledge test to identify the bases obtained from the selected unit.

To follow up with the students in the development of the activities and the time spent, a record of multiple sheets of the students was made to calculate the handling times and some important characteristics of access to the Smilearning application, this process was carried out in the first months of 2019 until the end of the semester, being used during 574 h: 19 m hours by eight students.

During the development of the activities proposed in the didactic sequence, a control was carried out to record the time used in the Smilearning platform when carrying out each of the activities and challenges proposed to reinforce the knowledge of the subject. In addition, it was observed that the periodontics graduate students of the Cooperative University, Bogotá headquarters use IOS or Android mobile devices with internet access, to work at any time.

The Smilearning system records the activities carried out by the students, specifies the duration and the process carried out detailing each of the proposed activities, including the participation of students in the tool’s discussion forum.

Activities analyzed with the Smilearning tool

- Proposed themes subcategorized
- Search terms
- Study of clinical cases
- Reinforcement with multimedia elements
- Discussion forums
- Events and planned activities (Fig. 2)



Once the course was completed, the data revealed that the entire application was used for 574 h and 19 min, showing a great interest on the part of the participants in developing collaborative learning between the teacher and the students.

By obtaining the collected information, the time used by the students in each of the subcategories was calculated, resulting in Fig. 1, which shows the support in knowledge and the development of collaborative learning. For example, we used the subcategory of discussion forum at 153 h: 10 m, an important means of communication between students and teachers; Then we have the proposed topics for the subject that are used in a range of 93 h to 41 h and finally the access to extra tools such as the presentation of clinical cases and video tutorials (Fig. 3).

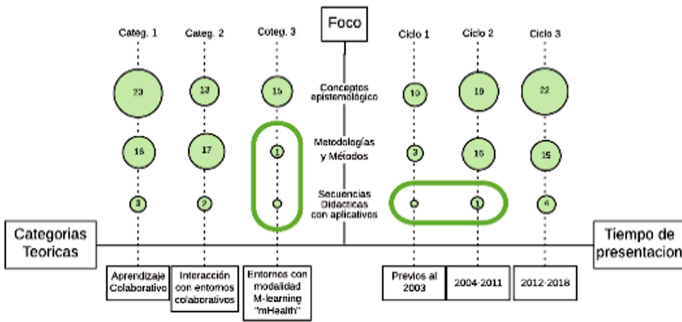


Fig. 1. Bubble diagram - systematic mapping (Note: own elaboration).

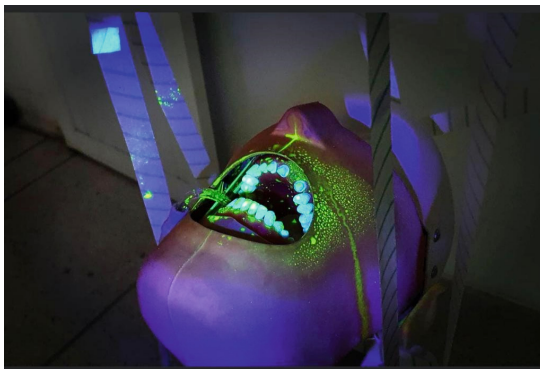


Fig. 2. Augmented reality from the first shot in the oral cavity. Smilearning app.

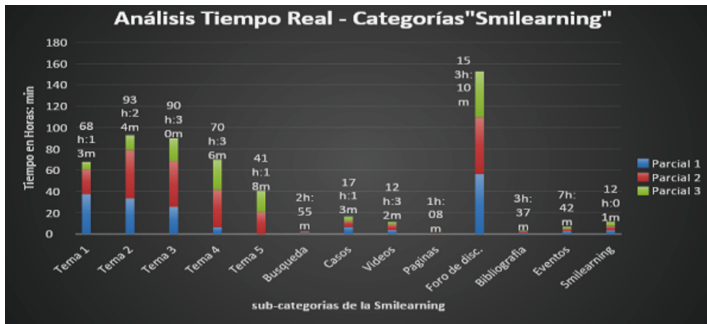


Fig. 3. Real Time Analysis - Smilearning Categories (Note: own elaboration)

## 5.2 Pedagogical Usability Test

Obtaining the usability heuristics: From the examination of different types of usability principles and recommendations for general purpose mobile applications, a set of heuristics was obtained to guide the process of designing and building web applications.

According to Burriel, by referring exclusively to the set of usability criteria associated with each of the 7 heuristics described in Sect. 4. All these relationships are structured and evaluated in a range of 0 to 5, with 0 being the absence of the criterion in the application and 5 the maximum compliance with the criteria within the application. It is then within this analysis that the criteria of the web or mobile application in question can be observed, the tool offers the evaluator the possibility of choosing the option (N/A). Therefore, within these relationships at the design level, the tool is based on tabs, each of which includes a heuristic and its associated criteria.

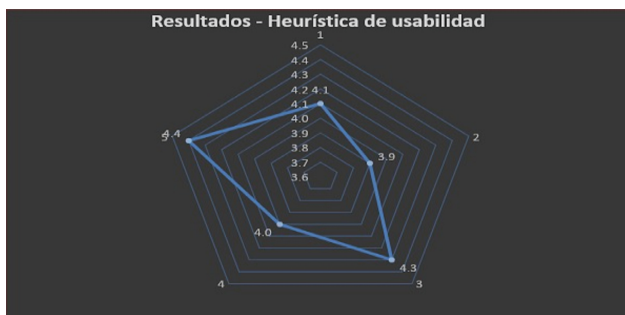


Fig. 4. Results

Figure 4 shows the results obtained for each use criterion, indicating the heuristics levels used, where H5 and H3 meet the highest level of the criteria assessed. The options taken for the application are defined below:

- Content: it represents a space to complement the thematic development with the students.

- Personalization: it represents an illustrative environment that generates an environment on the topic “Oral periodontic anatomy”.
- Social interaction: a space is designed in which students can communicate with their classmates and with the teacher in charge.
- Multimedia: within the application, a category is generated obtaining a list of videos and a link that reinforces the knowledge of the topic.
- Activities and tasks: finally, a set of tasks was selected to complement the knowledge received by the application.

## 6 Conclusions

The investigation provided elements of judgment by deducing that the application with augmented reality in the subject of oral periodontics when used was employed as didactic mediation. For this, it is necessary to know the T generation (corresponding to the current generation) that leads this mediation, taking into account the thematic contents are developed with suitability.

Based on this research with a descriptive-quantitative design, and after the analyzing the results, it is concluded from the research experience of phase II in this period called by the WHO covid 19 pandemic, this type of effective mediation is of great importance to improve learning outcomes, which is supported by higher education institutions.

The design of the activities in the didactic sequence of oral pathology topic, generates motivation in M-Learning and provides a real-time supervision of intellectual learning systems in the Smilearning application; these are factors that influence collaborative learning and the interaction between students and teachers.

The mHealth application in the subject of oral pathology is useful for mobile application learning activities (M-Learning), since it facilitates the creation of content, interaction and offers possibilities for personalization. Some of the outstanding advantages are: flexibility, personalization with multimedia, collaborative work and accessibility.

The new forms of interaction and the different actors that coexist in the network suggest new forms of collaborative learning in virtual communities, taking into account the various existing actors: subjects, objects, agents, mobile applications. Therefore, it is important to continue with the analysis of interactions, roles, profiles and behaviors in virtual communities. Without losing sight of the observation towards the real and offline. The effects, relationships and social and cultural changes that are created.

In this way, the Smilearning application improved learning outcomes in the student's academic activities. The teacher can define criteria or attributes to evaluate and monitor the collaboration process, following up in real time; necessary in the decisions making about how and when to intervene, when determining the degree of learning achieved by each student in each stage of the collaboration activity. It provides students with the necessary information on participant-content collaboration and their level of knowledge. The use of applications in M-Learning learning provides quick information to the teacher or the student, in the decision making in each collaborative activity. Although it is difficult to monitor the work of two groups at the same time, this work was done with the help of the Survey monkey program. This allows the teacher to monitor all groups during the collaborative activities. In this way, students and teachers are provided with adequate mechanisms to improve collaborative activities.

The analysis of the results suggests that the strategies in the group work adopted by each member are related to a successful process of individual construction of the cognitive context and the experience shared by the group members. Therefore, it is important to improve the development of strategies and facilitate their implementation; This was generated in the didactic sequence, making the language somewhat homogeneous, clear and unequivocal when referring to the common characteristics of the problem. The main contribution of this research is the approach of three elements directly related to the positive perception of pedagogical presence by students, namely: feedback, academy, and socialization. In general, both students and teachers consider that the contribution of peer interaction makes learning important.

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