M-LEARNING: DEVELOPMENT AND EVALUATION OF AN APPLICATION FOR THE TEACHING AND LEARNING OF HUMAN ANATOMY

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SUMMARY

This paper about m-learning reports the development and evaluation of an application for the teaching and learning of human anatomy. Twenty-six first term students of the Physical Education and of the Dance Studies courses (2015) took part in this action research, comprised by five stages. Quantitative and qualitative analysis of data were performed using the Student's t test and the Bardin model, respectively. The results showed that students were greatly interested and receptive to use m-learning strategies in their academic life. Comparison of pre- and post-test scores indicates a significant increase in correct answers. The subjective evaluation of the application showed its success, since students perceived the contributions of the development, use, and evaluation stages. The hosting service used in the application development was appropriate in terms of the objectives of this research.

Introduction

The education environment is currently experiencing growing pressures to adopt digital technologies (Moran *et al*., 2012). Research has shown that technological resources, based on a variety of approaches that complement traditional methods, enrich and widen the spectrum of conditions necessary to acquire and develop knowledge (Cardoso and Burnham, 2007).

However, Dias and Araújo Júnior (2013) maintain that the context of digital technologies requires a different paradigm for teaching and learning processes. This paradigm should promote the required changes in the current educational scenario. For example, a considerable body of research on scientific education in school and academic scenarios has investigated the use of digital technologies in teaching and learning methodologies.

Among the technological resources available today (smartphones and tablets), wireless connection and the widespread use of applications stand out. This new scenario is changing the way we interact with information, pointing to the greater potential to transform the way to teach and to learn (Nichele and Schlemmer, 2014).

It was thus that mobile learning, or m-learning emerged. Defined as a new education approach where teaching and learning processes are based on wireless mobile devices, m-learning is characterized essentially by the physical and temporal mobility it affords both to students and teachers (Saccol *et al*., 2012; Kurtz *et al*., 2015).

Technologies have been proven to be an opportunity for change in education. This change aims to meet the student's learning demands, and manifests itself mainly as a shift in focus from the teacher-centered to the student-centered practice. Mobile technologies represent an important advantage to the teaching processes, since they abolish restrictions in time, place and the way we learn (Maltempi, 2008; Barcelos *et al*., 2009; Moran *et al*., 2012).

Previous research predicted the success of pedagogical practices based on m-learning as a methodological approach. For instance, Batista and Barcelos (2013) concluded that m-learning may be a useful tool in pedagogical practices directed to research and production. These contributions by digital technologies are certainly a key aspect in the development of new professionals. In light of the relevance of digital technologies, we investigate the pedagogical use of these methods, namely of mobile applications, or m-learning, in the teaching and learning of human anatomy in higher education courses on health science.

Human anatomy studies the body structures and the relationships they have with one another (Arruda and Sousa, 2014). For this reason, anatomy is considered a fundamental discipline, extremely important in health science courses. Essential disciplines play an important part in the development of students and of the professionals of the future (Lopes *et al*., 2013). The unquestionable relevance of anatomy and the constant evolution of educational technologies point to the need for educators and health professionals to reflect about the use of technology-based pedagogical practices (Fornaziero *et al*., 2010).

In this sense, the objective of this study was to develop and evaluate a dedicated application for the teaching of human anatomy. In addition, the ensuing discussion of the use of digital technologies will be useful to professors as a reference study, which may help them create, together with their students, their own applications, spreading a culture of re-elaboration and re-signification of knowledge. It is important to note that, according to Rosa (2011),

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M-LEARNING: DESARROLLO Y EVALUACIÓN DE UNA APLICACIÓN PARA LA ENSEÑANZA Y APRENDIZAJE DE ANATOMÍA HUMANA

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RESUMEN

El objetivo de este trabajo fue elaborar y evaluar una aplicación de m-learning *para la enseñanza y el aprendizaje de anatomía humana. Participaron 26 alumnos de los cursos de Educación Física y Danza del primer semestre de 2015. El análisis cuantitativo se llevo a cabo usando el test t de Student y el análisis cualitativo utilizando el modelo de Bardin. La propuesta se organizó en cinco etapas. Los resultados mostraron que los alumnos muestran gran interés y receptividad a utilizar estrategias de* m-learning *en su vida académica. La comparación del pre- y el post-test muestran un aumento significativo de repuestas correctas. En la evaluación subjetiva de la aplicación, los propios alumnos destacaron el éxito de la misma, percibiendo las contribuciones de las etapas de elaboración, utilización y evaluación de la aplicación. El servicio utilizado para la elaboración de esta aplicación demostró ser adecuado para las necesidades del estudio.*

M-LEARNING: CONSTRUÇÃO E AVALIAÇÃO DE UM APLICATIVO PARA O ENSINO E A APRENDIZAGEM EM ANATOMIA HUMANA

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RESUMO

O objetivo desta pesquisa em m-learning *foi construir e avaliar um aplicativo para o ensino e a aprendizagem de anatomia humana. Participaram 26 alunos dos cursos de graduação em Educação Física e Dança no primeiro semestre de 2015. Optou-se por análise quantitativa utilizando o teste t de Student e análise qualitativa conforme o modelo proposto por Bardin. A proposta foi organizada em cinco etapas. Os resultados revelaram que os alunos apresentam grande interesse e receptividade em utilizar estratégias de* m-learning *em sua vida acadêmica. Os resultados do pré-teste e do pós-teste indicaram um aumento importante e significativo de acertos nas questões propostas no pós-teste. Na avaliação reflexiva, os próprios alunos destacaram o sucesso da proposta, percebendo as contribuições das etapas de construção, utilização e avaliação do aplicativo. O serviço utilizado para a construção do aplicativo demonstrou-se adequado às necessidades desta pesquisa.*

there are no ready recipes for using digital technologies. And this is not the aim of this research. In actual fact, we aim to foster a discussion that may help think about and learn how to use technologies based on the opportunities that may emerge.

Methodology

Characterization of the research

The approach used to carry out this study was that of action research, chosen because it is based on a process that follows a cycle in which practice is perfected by the systematic balance between proactively working in the field of practice and the investigation thereof (Tripp, 2005).

Participants

Participants included 26 students of a private university in the Greater Porto Alegre area, Rio Grande do Sul, Brazil. All participants were students of physical education (major and baccalaureate) and dance (major) attending classes in the first term of 2015.

Data collection instruments and data analysis

Data were collected using questionnaires. For quantitative analysis, the answers were analyzed using descriptive and inferential statistical tools. Pre- and post-test scores were compared using the Student's t test. Differences were considered statistically significant when $p<0.05$. Statistical analysis of data was carried out using the software Bioestat 5.00®.

For qualitative analysis, the answers given in the subjective evaluation were analyzed based on a set of techniques of content analysis, following the model proposed by Bardin (2011).

Procedures

Procedures were planned according to Parsons *et al*. (2007), with special emphasis on some aspects to be considered in m-learning projects, among which design aspects (students' habits and profiles, support to mobility, interface, and media), learning context (students' identity, activity and communication), learning experience (goals, results, and social interaction).

In this sense, this project was organized in five stages. In the first, the idea was introduced to students, points were clarified, and consent forms were signed by participants. Also, a questionnaire about the students' group profile was answered and an e-mail list was prepared. In addition, the pre-test was carried out a test to evaluate the students' previous knowledge about the concepts that would be covered during the development of the application, and students were grouped in study units based on affinity. In the second stage the teacher gave an expositive-dialogued class. In the third, m-learning strategies were organized using an adaptation of the method described by Saccol *et al*. (2012), summarized in Table I. The fourth stage, which was important to characterize this study as action research, included adjustments to the project. We followed the guidelines described by Tripp (2005) about action research, which define it according to four fundamental procedures: to act in order to implement the planned improvement, to monitor the effects of the action, to evaluate the results, and to plan an improvement in practice. The fifth and last stage included the post-test (a test to measure the acquisition of the concepts by students after the development and use of the application) and the subjective eva-

TABLE I
M-LEARNING STRATEGIES APPLIED TO EDUCATIONAL ACTIVITIES *

Strategy	Description	Use of cell phone	Activities	Pedagogical contributions
Identification of the object in the real world	Students took photographic records of anatomical parts	To photograph, to investigate	Students formed groups to identify anatomical parts, take photographic records and choose the best images	Record Production Storage
Collaborative decision-making	Students were challenged to produce summaries discussing ideas	To investigate	The group discussed the best way to round up the idea based on an summary written collaboratively.	Collaborative construction
Synchronization with the application	Students sent pictures and summaries to the professor	Communication tools (e-mail, social networks) Application download	Material was sent to the professor and the application was downloaded	Sharing between the group members Use of the application

* Adapted from Saccol *et al.* (2012).

luation. In all stages we followed the recommendations given by Parsons *et al.* (2007), which underline the fact that content has to be presented in small parcels, depending on the support afforded by each medium and which activities require the participation of students in the learning process. Interpersonal contact and communications were also stimulated using group work and discussions.

Results and Discussion

This section is organized as follows: students' profile questionnaire (designed to explore the technological profile of students and their learning context preferences), the pre- and post-test (to analyze the project from a statistical perspective and evaluate the difference between mistaken answers before and after the development and use of the application), the subjective evaluation (to shed light on the students' perceptions about the development and use of the application, and, in a broad sense, about their learning process), and the description of the application developed.

Students' profile questionnaire

For Parsons *et al.* (2007), design aspects as well as the learning context and background are important factors in the success of pedagogical projects based on m-learning. In the present study, information was obtained using a questionnaire with open and closed questions. In addition, the analysis of the context as observed before the technological intervention is, according to Santoyo *et al.* (2015), the key to best implement the strategy used. A summary of the answers given by students, considered from the perspectives of authors who also analyze the subject, is presented below.

The use of digital technologies is not a new subject in the academic environment. It is known that technological developments have prompted educational institutions to leave behind the traditional spatial setting to embrace new, multiple, more dynamic and elusive spaces (Albarracín *et al.*, 2015). In spite of the widespread new technology-based research and methodologies, all students who participated in the present study claimed that they had never taken part in learning technology-based activities in the academic environment. In this sense, Marcon and Dias (2014) notes that, currently, it is virtually impossible to know someone in large cities who has no internet connection. This means that there is a gap between the experience developed in the academic environment and the current reality.

The results of the present study point to a similar scenario, since 43% of the students revealed that they spend the whole day connected to the internet, of which 77% use the 3G band. Marcon and Dias (2014) concluded that, today, people stay connected for much longer, with real-time access to information and interacting from home as much as from any other place at any moment in time.

Smartphones have become popular in tandem with the number of people who spent the whole day connected to the internet. This was confirmed when participants were questioned as to the device that they use for this purpose: 77% declared that they resort to smartphones. Side by side with the increasing use of smartphones, we also notice the number of people who use 3G wireless connections to connect to the internet via cell phone (Rosado and Tomé, 2015). In the present study, 97% of students access the internet using a cell phone. In recent years the cell phone market experienced growth at an unimaginably high rate, making it the most successful electronic gadget in the world (Junior and Silva, 2015).

In line with the expansion of the use of cell phones, applications are also becoming increasingly popular in the cyberspace (Souza and De Luca, 2015). In this sense, most students (73%) indicated that they usually download apps. Among the most common ones are the game apps and social networks plugins, both downloaded by 35% of the students. Music apps account for 15% of downloads, health and exercise apps 15%, and photo editing apps 12%. In a study about the use of cell phones as a learning tool, Santos and Santos (2014) reported that most students use smartphones solely as a means to exchange messages and log in to social networks, which indicates that this technology is underutilized.

Despite the popularity of smartphones, the results indicate that the status of the students' knowledge about digital technologies, more specifically informatics, is rather poor. Most students (69%) declared having elementary informatics knowledge and admitted to the need to dedicate pedagogical effort to learn how to use digital tools. In this sense, Vendruscolo *et al.* (2005) believe that new demands concerning digital technologies should be addressed in all learning contexts.

After all, it is by embedding digital technologies in the educational environment that digital inclusion is promoted. Defined as the effort to effectively include the subject in the digital world, digital inclusion makes available the tools necessary to interpret the symbols used by the digital society and the whole logic underlying the use of these tools (Santos and Rafalski, 2015).

Internet affords access to a massive body of information and, in this sense, the worldwide web is an important facilitating tool in learning (Martins and Silva, 2015). The students who took part in this study acknowledge internet's potential, since 88% indicated that they use it as a ancillary tool in their studies. Of these, 85% declared that they use internet as a source for research, especially of texts (31%) and videos (12%).

Proceeding with the survey on the context and the experience in learning, students were questioned as to the time they dedicate to learn human anatomy. In this sense, 31% answered that they spare between 1-2h daily for the purpose. Fifty percent of the students believe that they spare a suitable length of time to study anatomy, while 25% think that they might do better if they studied more. The same percentage declared that they definitely need to spend more time reviewing contents, even though 69% of respondents declared that the discipline is considerably significant for their performance in their future professional life. Another interesting aspect is that, for Piazza and Chassot (2011), human anatomy is a traditional discipline in health courses, and is considered essential for health professionals. Piazza (2011) adds that human anatomy is included in numerous curricula in health science education.

Ninety-two percent of students answered that they use other resources as a supplement to the studies in campus, among them the internet, books, and images and videos about the topics covered in the classroom (77, 31 and 15%, respectively). It was observed that students look for other tools (internet and books) and strategies (images and videos) for this purpose. Zabala (2010) draws attention to the fact that the professor has to master these tools and strategies in light of the students' preferences regarding learning in order to include them in lesson planning.

The last question in this stage of the study addressed the students' knowledge about the topic that was being taught in the classroom, the articular system. It was found that 73% of students did not have previous knowledge about it, although the topic is usually covered in more elementary education, specifically in the science course of the 8th grade in elementary school and in the second year of high school.

These questions, which revealed the students' profile, their preferences and experience with learning in different contexts, were of importance in the present study, since they reveal methodologies, tools, and projects that may be used to more effectively approach the group and therefore adapt the teaching and learning process to each one individually.

Pre- and post-test

Pre- and post-test scores were significantly different (Student's t test p=0.002). This means that the same group was observed before and after the implementation of the project (Moreira, 2003). In addition, we observed a 47.5% increase in correct scores in the post-test. These results allow to conclude that the higher number of correct answers is due to the project, though Moreira (2003) believes that the project may not have been the reason behind this improvement, due to the experimental design adopted.

All questions in both tests were of the open type. Question 1 covered the definition of joint. Fifteen students did not get the correct answer in the pre-test, while in the post-test this number fell to zero, indicating that the definition of joint was assimilated by the students.

Questions 2 and 3 were about the functional and the structural classification of joints, respectively. These questions presented the highest rates of wrong answers in the pre-test. Four students gave a wrong answer to question 2. For question 3, no student got the right answer. However, in the post-test this number was four and eight for questions 2 and 3, respectively.

Question 4 covered the concept of joint mobility. Twenty-two students answered this question incorrectly in the pre-test, while in the post-test this number fell to two. Question 5 was about the concept of mobility and its role in movement of limbs. Eleven students did not get a correct answer in the pre-test. In the post-test, all students produced right answers.

The results point to a significant improvement in the understanding about the topics: definition of joint, functional and structural classification, mobility, and role of joints in movements of the human body.

Subjective evaluation

The evaluation stage started on the week after the end of the last stage of application development. In this evaluation, students answered a questionnaire about the use, the loading time, the data and, the difficulty to download it, among other subjects. This stage was based on Parsons *et al.* (2007), who consider the importance of the results of the learning experience. In addition, it is also important in the context of the evaluation of the students' perceptions as to the teaching and learning processes.

The results show that the application enjoyed good acceptance by students, who demonstrated interest in it, since 77% downloaded the software. Of these, 62% believed that it is easy, simple, and practical (20%), and includes clear images and succinct explanations (10%). In an exploratory study, Batista *et al.* (2010) demonstrated that students have the skills to use devices and are receptive to them in educational contexts. In the present study, 90% of the students did not report any difficulty to download the application. But the 10% who claimed that the application was difficult to download declared that they managed to overcome these difficulties after reading the download directions. Among the 38% who answered that the application is not simple to use, 10% mentioned the need for an internet connection and 20% cited the long loading time of images.

Santos and Santos (2014) underscore the growing importance of mobile devices in everyday life. In the present study, for 60% of students the application was useful to improve study time, since it is practical and portable (83%), contributing to learning the content. Similarly, 75% of participants considered the data contained in the application useful and relevant to their studies.

Similarly to Kalloo and Mohan (2012) in a study of mathematics m-learning carried out in Trinidad and Tobago, we also observed how enthusiastic students were with the use of the cell phone as a learning tool.

Subjective analysis allows students to express their opinions, which are useful as a means to discover what they think about their own learning process. In addition, these analyses are important to the professor, in that they permit to identify preferences and experience in learning. In this sense, since 90% of students stated that the application development stage contributed to the teaching and learning processes, it is possible to assume that the adopted strategy was effective.

In turn, the students declared that the application helped them learn human anatomy, since it can be used at any place and time (21%), it is easy to understand and access (21%), and it releases them from carrying around heavy books (11%).

The use of technology reveals that the role of a professor acquires a new meaning, which is that of creating the conditions for students to engage in learning activities. To that end, the professor has to conceive situations that facilitate learning, taking into consideration the contents to be transmitted and the best way to do it (Asbahr, 2005).

The application

The application was developed and made available by *Fábrica de Aplicativos* (http://fabricadeaplicativos.com.br/), an online service for smartphone application development. It allows developing software with available functions (image, sound and video galleries, text lists, Facebook, Flickr, message boards, and others). We used the free version of made available by the service.

Students produced materials that were embedded into the

application. After five classes on developing materials and adapting the application, it was made available for download by an e-mail link to students.

Called '*App Anatomia Humana*', the application (Figure 1) is divided in ten tabs: introduction, the joints, conceptual map, morphological types, condylar images, spheroideal images, ginglymus images, plane images, saddle images, and trochoid images. The original language of this manuscript (Portuguese) has been maintained in the illustrations so as to demonstrate exactly the visualization of images to which students had access to.

The tab 'Introduction' is subdivided in other two, 'Did you know? and 'About the App'. In the first one, a short introductory explanation about the theme is given, as a way to encourage students. The second includes a detailed description of the objective of the didactic project of developing the application. A list of credits concerning the didactic material and the development of the study is also given.

The tab 'The joints' presents the definition of joint as conceived by the group of students taking part in this research. The 'Conceptual map' tab introduces a conceptual map prepared by the professors who conceived this study. 'Morphological types' includes a description of the classification of synovial joints (Figure 2). It has six subsections: condylar, espheroideal, ginglymus, saddle, and trochoid synovials. These provide information about accidents involving bones, possible movements, and examples (Figure 3).

All didactic content included in the application was developed during the study. The images and respective identifications, definitions, and examples were prepared by the students, as described above in the third stage on 'procedures' of Methodology.

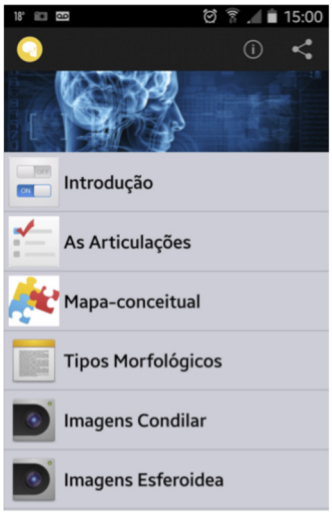

Figure 1. First screen of the application *App Anatomia Humana*. http://galeria.fabricade aplicativos.com.br/app_anatomia#gsc.tab=0

Figure 2. Morphological Types tab. http://galeria.fabricadeaplicativos.com.br/app_ anatomia#gsc.tab=0

Figure 3. Tab for condylar synovial joint and respective information. From http://galeria. fabricadeaplicativos.com.br/app_anatomia #gsc.tab=0

Since a free version of the service made available by *Fábrica de Aplicativos* was used, the application remains visible in the app gallery to any user. At the time this paper was completed, *App Anatomia Humana* had been downloaded 203 times. In other words, a considerable number of users, over the 26 students who participated in this study, downloaded the application, indicating the wide reach of this kind of research.

Final Considerations

The aim of this study was to develop and evaluate an application to teach human anatomy. With that in mind, we chose a methodology that allowed students a new interpretation of knowledge, based on research, information selection, and collective decision-making. The project was evaluated using a set of quantitative and qualitative tools so as to afford full interpretation of the results.

Results show that students are greatly interested and receptive as to the use of m-learning strategies in their academic life. M-learning proved to be a useful tool to better use study time since, despite its importance, students spare little time to study human anatomy.

Comparison of the pre-test and post-test scores signal an important and significant increase in the number of correct answers. However, due to the pre-experimental character of this research, it is not possible to state that this increase is a result of the use of the application. In this sense, further research should be conducted to improve the m-learning strategies and design.

The subjective evaluation showed that students understood the contributions of the development, use, and evaluation stages, underlining the success of the application. In addition, the service used to develop the application, *Fábrica de Aplicativos*, was appropriate considering the aims of this study, meeting the students' demands and, at the same time, the objectives of the authors.

It is possible to conclude that m-learning is a fruitful field of research, which may contribute to the adaptation of teaching practices to current needs, apart from improving students' performance, promoting digital inclusion, and meeting the recommendations of the scientific education community on teaching and learning scenarios.

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