CONCLUSIONS

This study aimed to look a little deeper into the performance in science of the Brazilian students in the PISA, raise questions and make some reflections about the above mentioned results. In general, the results reproduce the usual findings of the literature that claims that the social, scientific and technological development of Brazil requires a major overhaul of the educational structure in the country (See Schwartzman, 2004; Carnoy with Gove and Marshall, 2007; Barros and Ferreira, 2009).

The results obtained by the Brazilian students place the country at a disadvantageous position compared to almost every country participating in PISA. Brazil was the 52nd country in scientific competence among the 57 participants in PISA 2006. By all means, the country is placed in the level 1 of the PISA performance scale, but there is still a significant margin of Brazilian students who cannot even achieve this, which is the lower level considered by the programme. It was not the goal here, however, to develop a comparative study between Brazil and the other countries participating in this programme. Recognizing and taking into consideration the socio-economic and cultural differences among the various participating countries was not done in this study. Although rudimentary, this study identified the effect on student performance of the socio-economic background and the school administrative dependence to which Brazilian students are exposed. Variables such as color, sex, grade failure, etc., are also known to be related to student performance variance and should also be investigated in a larger scope study.

The 2006 PISA data showed that students not enrolled in a private school and who do not come from high-income families have a considerable disadvantage in science. It also showed that the fact of being enrolled in a public school is alone substantially enough to explain the variance of the mean

performance in science of Brazilian students. Science education is important for citizens to help them face new challenges and new work opportunities as the modern world changes around them. This education is a significant step towards securing a better future for all (Cury, 2002). The right to education and quality education is one of those steps that have not lost importance nor lost its relevance.

AKNOWLEDGEMENTS

To Vedrana Ljuljovic for the critical reading of the manuscript and to FAPERJ - Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro for the grant.

BIBLIOGRAPHY

ABC. Academia Brasileira de Ciências. *O ensino de ciências e a educação básica: propostas para superar a crise*. Rio de Janeiro, Brasil, 2008. 56p.

Barros, R.; Ferreira, F. *Measuring Inequality of Opportunities in Latin America and the Caribbean*. World Bank. Washington DC, USA, 2009. 165p.

Brasil. *Parâmetros Curriculares Nacionais: ciências: 5ª a 8ª séries*. MEC, Brasília, Brasil, 1998,138p.

______. *Resultados nacionais – Pisa 2006: Programa Internacional de Avaliação de Alunos (Pisa)*. INEP, Brasília, Brasil, 2008. Disponível em: < http://www.inep.gov.br/download/internacional/pisa /PISA2006.pdf >. Acesso em: 12 Abr. 2015.

Carnoy, M.; Gove, A.k; Marshall, J.h. *Cuba's Academic Advantage: Why Students in Cuba Do Better in School*. Stanford University Press, Stanford, California, 2007, 209p.

Coleman, J.S. *Report on equality of education opportunity*. US Government Printing Office for Department of Health, Education and Welfare, Washington, DC, United States, 1966, 575p.

Cunha, L.A. *Educação e desenvolvimento Social no Brasil*. F. Alves, Rio de Janeiro, Brasil, 1975, 293p.

Cury, C.R.J. Direito à educação: direito à igualdade, direito à diferença. *Cadernos de Pesquisa*, [116], 245-262, 2002.

Forquin, J.C. As abordagens sociológicas do currículo: orientações teóricas e perspectivas de pesquisa. *Educação e Realidade*, **21**, [1], 187-198, 1995.

Franco, C.; Ortigão, M.I.R.; Albernaz, A.; Bonamino, A.M.C.; Aguiar, G.S; Alves, F.; Satyro, N. Eficácia escolar en Brasil: investigando prácticas y políticas escolares moderadoras de desigualdades educacionales. In: CUETO, S. *Educación y brechas de equidad en América Latina*, Fondo de Investigaciones Educativas / PREAL, Tomo I, Santiago, Chile, 2007, p. 223-249.

Marks, G.N.; Cresswell, J.; Ainley, J. Explaining socio-economic inequalities in student achievement: the role of home and school factors. *Educational Research and Evaluation*, **12**, [2], 105-128, 2006.

OCDE. Organization for Economic Cooperation and Development. *Literacy skills for the world of tomorrow: further results from PISA 2000*. Organization for Economic Co-Operation and Development, Paris, France, 2004, 25p.

OCDE. Organization for Economic Co-operation and Development. *PISA 2006 Technical Report*. Organization for Economic Co-Operation and Development, Paris, France, 2007, 416p.

OCDE. Organization for Economic Co-operation and Development. *BRAZIL – Country Note – Results from PISA 2012*. Organization for Economic Co-Operation and Development, Paris, France, 2013, 12p.

Patto, M.H. *A produção do fracasso escolar: histórias de submissão e rebeldia*. 2.ed. Casa do Psicólogo, São Paulo, Brasil, 1996. 464p.

Schwartzman, S. The chalenges of education in Brazil. In: Brock, C.; Schwartzman, S. *The chalenges of education in Brazil*. Symposium books, Cambridge, UK, 2004, p. 9-40.

Soares, J.F. Quality and Equity in Brazilian Basic Education: facts and possibilities. In: Brock, C.; Schwartzman, S. *The chalenges of education in Brazil*. Symposium books, Cambridge, UK, 2004, p. 69-88.

Teixeira, A. *Educação não é privilégio*. Editora UFRJ, Rio de Janeiro, Brasil, 1994. 146p.

Received 4-06-2016 /Approved 15-05-2017

Intelligent tutorial system for learning of basic and operational Math

Sistema tutorial inteligente para la enseñanza de las matemáticas básicas y operativas

Victor Daniel, Gil Vera

Fundación Universitaria Luis Amigó, Medellín , Colombia, victor.gilve@amigo.edu.co

Abstract

The basic math are the first encounter of students with university mathematics, which will enable them to acquire the fundamentals to support more advanced courses, such as calculus, statistics, physics, chemistry, among others. Here the importance of the teacher to provide an adequate mathematical education is important. Thanks to information and communication technologies (ICT), many tools and teaching strategies involve the use of electronic and digital resources (m-learning, b-learning, e-learning, etc.) to enhance the learning processes. Intelligent Tutoring Systems (ITS) extend traditional content computerized learning systems by adding intelligence to improve the effectiveness of a learner's experience. The main objective of this paper is to present the intelligent tutorial system "Cyber-Math", which brings together the topics and theoretical concepts of basic mathematics, which allow the student to learn at their own pace, because it can be accessed at any time and place if there is access to the internet. This paper concludes that the intelligent tutorial systems can transform the traditional teaching – learning model to a flexible, agile and didactic model.

Key words: *artificial intelligence, education, mathematics, m learning, ICT.*

Resumen

Las matemáticas básicas y operativas es el primer encuentro de los estudiantes con las matemáticas de la universidad, la cual les permitirá adquirir los fundamentos básicos para abordar cursos más avanzados, tales como cálculo, estadística, física, química, entre otros, de aquí la importancia que tiene el docente de impartir una adecuada formación matemática. En la actualidad, gracias a las tecnologías de la información y la comunicación (TIC), existe una alta diversidad de técnicas y métodos de enseñanza de la matemática que involucra el uso de recursos electrónicos y digitales (m-learning, b–learning, e-learning, etc), facilitando el proceso enseñanza

– aprendizaje. Este trabajo, tiene como objetivo principal presentar el sistema tutorial "Cyber-Math", el cual reúne las temáticas y conceptos teóricos de las matemáticas básicas y operativas que le permite al estudiante interactuar con las matemáticas, ya que cuenta con la posibilidad de acceder al mismo en el momento y lugar que desee solo con tener acceso a internet. Con este trabajo se concluye que los sistemas tutoriados permiten transformar el modelo tradicional de enseñanza – aprendizaje, en un modelo ágil, flexible y didáctico.

Palabras clave: *educación, matemáticas, m-learning, inteligencia artificial, TIC.*

INTRODUCTION

Intelligent tutorial systems (ITS) are a branch of the applied artificial intelligence (AI), whose main objective is to simulate the process of teaching of an expert in a specific area of knowledge, both in the domain of a specific topic as in the aspects related to pedagogy and in communicating with the user (Murray, 2003). The ITS are designed to guide the learning process of a user at any time and place, without the need to interact directly with an expert (Q Kalhoro, 2010). Interactive learning environments that support the acquisition of cognitive skills must provide opportunities for the learner to practice the target skill (Mitrovic, Ohlsson, & Barrow, 2013).

The teaching of basic mathematics in higher education has become a complex task, due to the amount of conceptual and procedural gaps that are evident in the majority of university students in first semesters. For this reason, the mathematical teachers have the need to repeat or reinforce mathematical contents of the high school, generating delays in the development of their courses. "*Cyber-Math*" allows the user to acquire or relearn the skills of basic and operational mathematics. This paper concludes that the (ITS) facilitate the learning process in any area of knowledge and make it possible to transform the traditional educational model into a versatile, flexible and didactic model.

INTELLIGENT TUTORING SYSTEMS

Intelligent tutoring systems (ITS) were used for the first time in the year 1970, as a way of providing greater flexibility to the learning strategy and achieve a better interaction with the user (Aguilar, Muñoz, Noda, Bruno, & Moreno, 2008). The ITS have provided a fertile ground for research in artificial intelligence (AI) over the past twenty-five years (Corbett & Koedinger, 1997). The main objective of the ITS is to capture the knowledge of experts to create dynamic interactions with users, enabling them to identify their strengths and weaknesses without having to interact directly with an expert human (Aguilar et al., 2011). ITS are sophisticated software systems that can provide personalized instruction to students, in some respect similar to one-on-one tutoring. Many of these systems have been shown to be very effective in procedural domains such as algebra, physics, etc. (Gutierrez & Atkinson, 2011). In many experiments, ITS induced learning gains higher than those measured in a classroom environment, but lower than those obtained with one-on-one interactions with human tutors (Gutierrez & Atkinson, 2011). ITS foster and assess learning through adaptive interaction between the student and the system, and the instruction contains both domain-specific pedagogical knowledge and knowledge of the learner (Nkambou, Bourdeau, & Mizoguchi, 2010) and (Sanchez, Bartel, Brown, & DeRosier, 2014).

The ITS are education systems based on computers that have models of instruction of content that specify what and how to teach (Murray, 2003). These have the ability to make inferences about the thematic domain in order to dynamically adapt its content, enabling students to learn by doing in realistic and meaningful contexts, and have more control over their learning (Murray, 2003). The main advantage of the ITS in comparison with systems traditional tutorials, lies in its flexibility, in both the approach and in the adaptation to the student. The traditional tutorials systems contain a large amount of rules and information, which can generate confusion (Aguilar et al., 2011).

The design of the ITS is based on the fundamental assumption that students learn better in situations that are closer to the situations in which they are going to use their knowledge, i.e., learn by doing, committing errors, and building knowledge (Ferreira & Atkinson, 2009). In summary, the ITS have the potential to introduce advances in the field of learning and education (Ramesh & Rao, 2012) and allow that learning to be performed at any time and place (Quratulain Kalhoro, Chowdhry, Abbase, & Abbasi, 2010). ITS offer strong learning gains, but are a class of technology traditionally designed for most-developed countries (Nye, 2015). ITS rely on detailed domain-knowledge which is hard to obtain and difficult to encode (Paassen, Mokbel, & Hammer, 2016). The main components of an ITS are:

Domain Model: consists of a representation of the domain to be taught (Virvou & Sidiropoulos, 2013).

Student Model: stores information about the student's performance or behaviors, including his/her knowledge level, his/her preferences, his/her learning history and helps the ITS to personalize the teaching strategy (Virvou & Sidiropoulos, 2013).

Teaching Model: contains a representation of the teaching strategies of the system and provides adaptive instructions to the students (Virvou & Sidiropoulos, 2013).

User Interface: provides the means for the student to interact with the ITS (Virvou & Sidiropoulos, 2013).

Importance of ITS in math and science

In the state of the art review it was found that the use of ITS in the teaching of exact and natural sciences: mathematics, biology, chemistry and physics are of great utility. Prior research has shown that students learn from ITS (Millis, Forsyth, Wallace, Graesser, & Timmins, 2016). For example, results from two pilot studies done in the lab and in the field with altogether 99 undergraduates suggest that ITS leads to significant and large learning gains on chemistry knowledge (Rau, Michaelis, & Fay, 2015). ITS produced statistically and practically meaningful learning gains on measures of arithmetic and algebra knowledge (Sabo, Atkinson, Barrus, Joseph, & Perez, 2013). Table 1, presents some educational software in math and science:

Name	Area	Developer
Calculus Math App Lite	Calculus	Neu Media Technology
Operation Math	Basic math	Spinlight
Math Academy	Basic math	SCIMOB
Biology	Biology	MoboTech
O-Level Biology	Biology	JSL Educational Services
O-Level Chemistry	Chemistry	JSL Educational Services
O-Level Physics	Physics	JSL Educational Services
Physics	Basic Physics	Diablo code

M - learning applications for the teaching of basic mathematics: related works

In this section, presents the search method used to identify works related with basic math applications for mobile devices. A search of literature reviews, articles, conference proceedings, abstracts and publications was developed in specialized databases. In addition, we reviewed articles published in the following journals: *Journal of Computer Assisted Learning (JCAL), Computers and Education, Journal of the Learning Sciences, International Journal of Mobile Learning and Organization, International, Journal of Computer-Supported, Collaborative Learning e International Journal of Learning Technology.*

The range of dates was understood from the year 2010 until the year 2015. In total, we inspected 44 conference publications of m-learning and 11 articles from specialized journals. The keywords used were: *education, intelligent tutoring systems, mathematics, m-learning applications.* In total we studied 55 publications. Search equations used were:

(TITLE-ABS-KEY (m-learning) OR (education) AND (((mathematics) OR (((ITS) OR ((basic) OR (applications)))) >2009

(TITLE-ABS-KEY (m-learning) AND (education) AND (((mathematics) AND (((ITS) AND ((basic) AND (applications)))) >2009

(TITLE-ABS-KEY (m-learning) AND (education) AND (((mathematics) OR (((ITS) AND ((basic) OR (applications)))) >2009

(TITLE-ABS-KEY (m-learning) AND (education) AND (((mathematics) AND (((ITS) AND ((basic) OR (applications)))) >2009

(TITLE-ABS-KEY (m-learning) OR (education) OR (((mathematics) OR (((ITS) OR ((basic) AND (applications)))) >2009

METHODOLOGY

The methodology used for the construction of "*Cyber-Math*" was the systematic literature review (SLR), systematic, auditable, and organized process that seeks to respond to one or more research questions (Kitchenham et al., 2009). A RSL is a means to identify, assess and interpret all relevant research available related to a question of research, thematic area or phenomenon of interest. The individual studies that serve as the basis for the realization of a RSL are called primary studies, the RSL alone is considered as a secondary study (Staples & Niazi, 2007). According to Kitchenham (2009), the steps of a RSL are the following:

- *Planning the review*: the output from this phase is a systematic review protocol that defines the purpose and procedures for the review.
- *Conducting the review*: this phase ultimately generates final results, but also generates the following intermediate artifacts: the initial search record and archive, the list of selected publications, records of quality assessments, and extracted data for each of the selected publications.
- *Reporting the review:* reporting the review is a single stage phase. Usually, systematic reviews are reported using two formats: in a technical report and in a journal or conference papers. The structure and contents of reports is presented in the guidelines

The research question considered in this work was *Q1. What are the main topics and theories of basic mathematics that must know university students?* The keywords used were *Intelligent Tutoring Systems, Mathematics, M-learning.* Additionally, we searched with these words mixed together. The search equation used was:

(6) (TITLE-ABS-KEY (intelligent tutoring systems)) AND ((mathematics)) AND (m- learning) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "MATH"))

The range of publication dates considered in the review was understood from the year 2010 until the year 2015. In total were collected eight publications between articles, conference papers, summaries, chapters of books and articles in development. Table 2 presents the number of publications by type collected in the review of the state of the art.

Table 2. Number of publications

Document Type	Documents	Bibliographic description
Conference paper	5	Glavinic, Rosic, & Zelic (2007) Glavinic, Rosic, & Zelic (2008a) Glavinic, Rosic, & Zelic (2008b) Henry & Sankaranarayanan (2009) Nye (2013)
Article	2	Khemaja & Taamallah (2016) Nye (2015)
Review	1	Kaklauskas, A., Kuzminske, A., Zavadskas, E., Daniunas, A., Kaklauskas, G., Seniut, M., Cerkauskiene, R. (2015)
Total	8	

Source: scopus

Additionally, a search of gray literature was performed, were collected 17 manuals published by Colombian universities, which were used for the construction of the knowledge base .

Design and structure

"Cyber – Math" was developed with the Xerte software, which provides a comprehensive set of open source tools for developers and creators of interactive didactical material (Xerte, 2015). Xerte is aimed at developers of interactive content who will create sophisticated content with some scripting. This software can be downloaded in the next address: http://www.xerte.org.uk/index.php?lang=es. The user must register and download the file *Xerte Desktop.* See Fig 1:

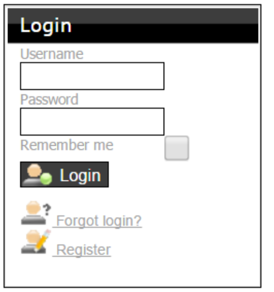


Fig 1: Access. Source: Xerte

Once downloaded and installed the program, the user must click on the option "Page Templates". See Fig 2:

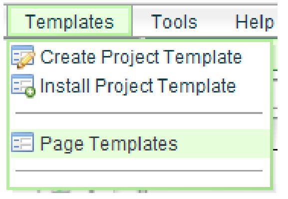


Fig 2: Templates. Source: Xerte

The program displays in the menu bar the options: File (New Project, Open, Save, Exit), View (Preview), Publish (Publish, Package), and Help. The toolbar contains three buttons: Insert (Text, Multimedia, Interactivity, Games, Connectors, Navigators and Misc), Copy, Delete, Optional properties, Add and Save. See Fig 3:

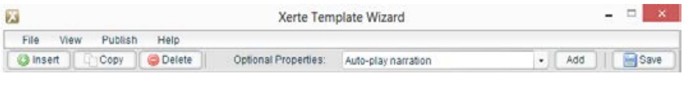


Fig 3. Menu and toolbar. Source: Xerte

The elements that are added to the LO is stored in the left-hand side. See Fig 4:

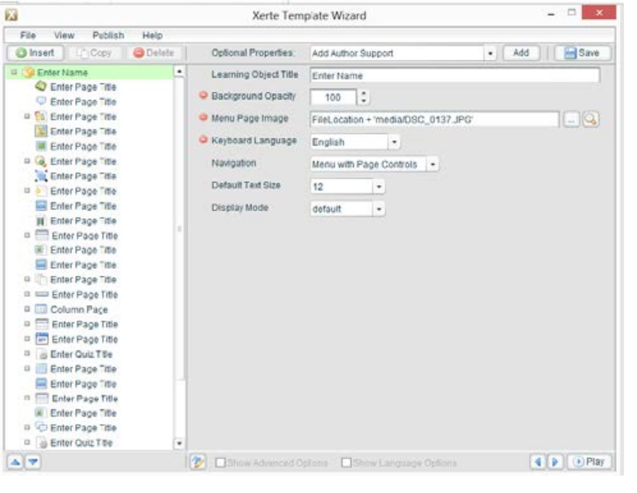


Fig 4. Elements. Source: Xerte

The user must configure the following items: background opacity (0 - 100), background image, language (English, French, German, Italian, Croatian) learning object title, navigation (linear, menu, menu with page controls), text size (10 – 36), display mode (full screen, fill window, default), custom interface, glossary, help file, icon, keyboard language, media file, media image, style-sheet. To save the changes click on "Save". See Fig 5:

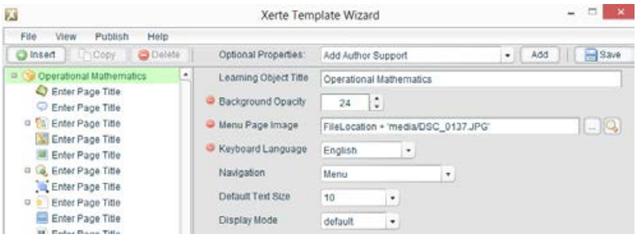


Fig 5. Configuration. Source: Xerte

To publish the learning object give click “Publish”. See Fig 6:

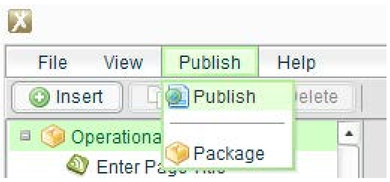


Fig 6. Publication. Source: Xerte

The “Title” element allows you to add a title to it, the user must specify the font size (20-70). Fig 7:

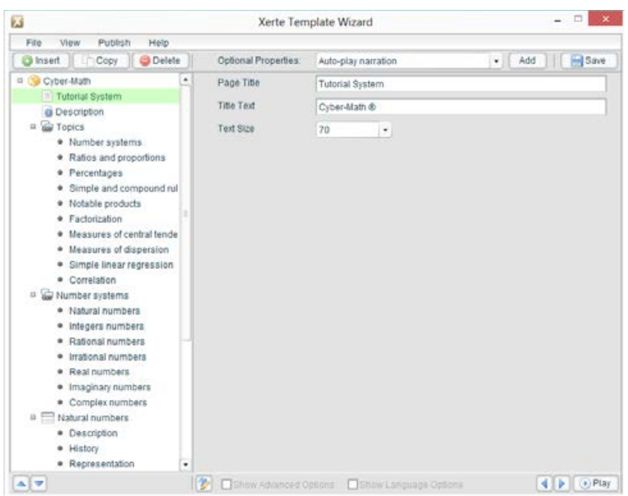


Fig 7. Title element. Source: Xerte

The “Description” element allows you to specify: page title, goals header, audience header, target audience, pre-requisites header, pre –requisites, how to reader and how to use. See Fig 8:

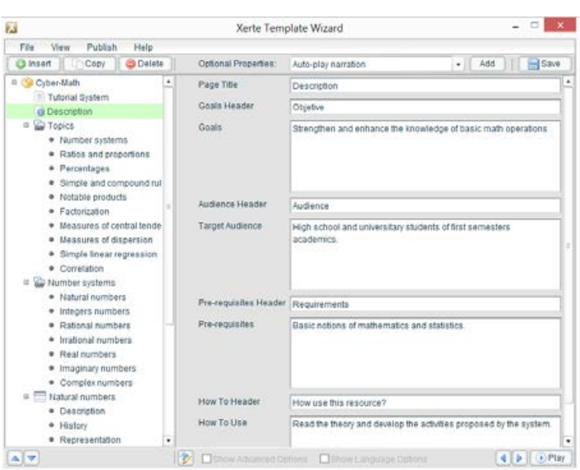


Fig 8. Description. Source: Xerte

The “Topics” element allows you to create the content table of the LO . The items redirected the user to the content that you want to know. See Fig 9:

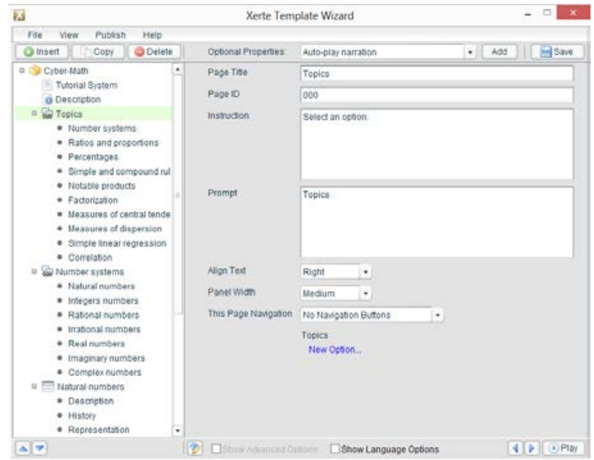


Fig 9. Topics. Source: Xerte

To create activities you must select in the “Insert” menu one of the next options: annotated diagram, button sequence, categories, dialog, drag and drop labelling, gap fill, hotspot image, and others activities. For example, Fig 10 presents a “Dialog” activity. In the section “Text” write the instructions for the user. See Fig 10:

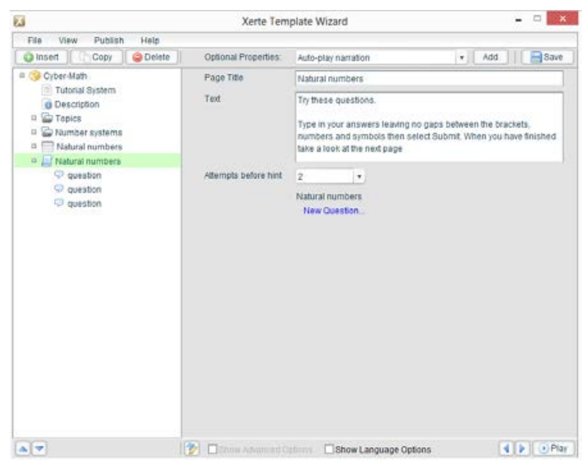


Fig 10. Topics. Source: Xerte

In the section “Question”, write the question, in the section “Answer”, write the correct answer and a brief “Hint”. See Fig 11:

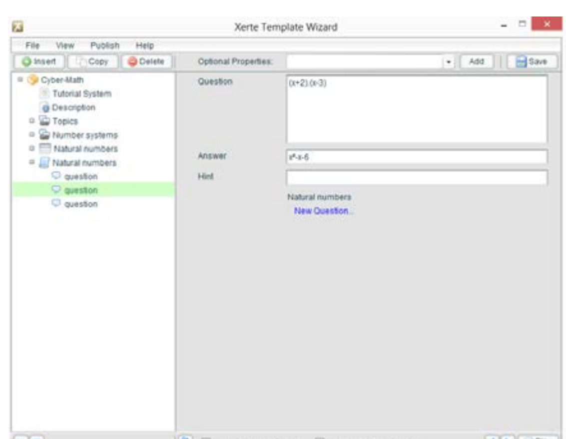


Fig 11. Topics. Source: Xerte

Similarly, the user can add other types of activities. To display the LO must press the “Play” button located in the bottom right.

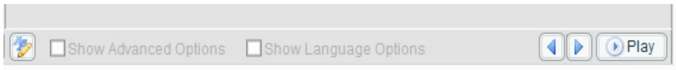


Fig 12: Display. Source: Xerte

METHODOLOGY

"*Cyber-Math*" works for mobile devices with Android and iOS operating systems with access to the internet and can be used on personal computers and laptops. Can be accessed from any browser (Google Chrome, Mozilla Firefox, Opera, Safari, Internet Explorer). The mobile device or computer must have installed the version 11.1 of Adobe Flash Player. To use it, you must access the following link: http://cybermath.wixsite.com/mobile ."*Cyber-Math*" presents the theory, concepts and fundamental notions that students must know. Fig 13 presents the initial interface of the system.

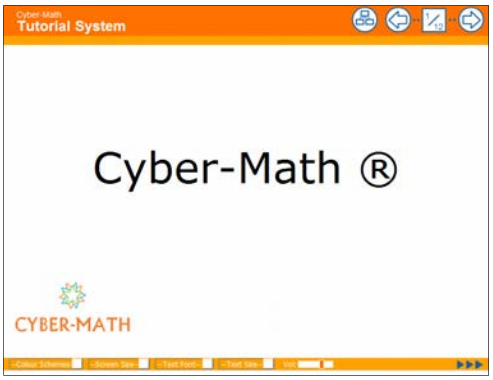


Fig 13: initial interface

Fig 14, presents the second interface, objectives, audience and how to use it.

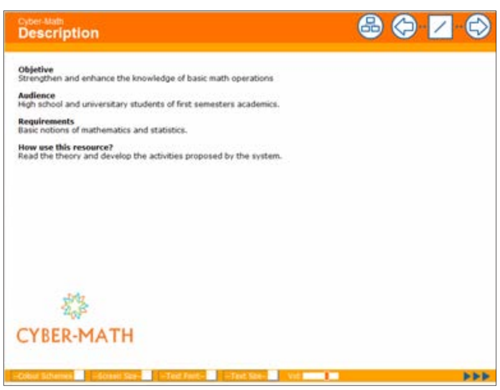


Fig 14: second interface

The Domain Model (DM) of "Cyber-Math" gathers the topics about the basic concepts of a basic mathematics course. The contents of the (DM) are*:* number systems, ratios and proportions, percentages, simple and compound rule of three, notable products, factorization, measures of central tendency, and measures of dispersion, simple linear regression and correlation. Each topic contains theory, exercises and test. Fig 15, presents the first activity proposed by the system belonging to the factorization topic:

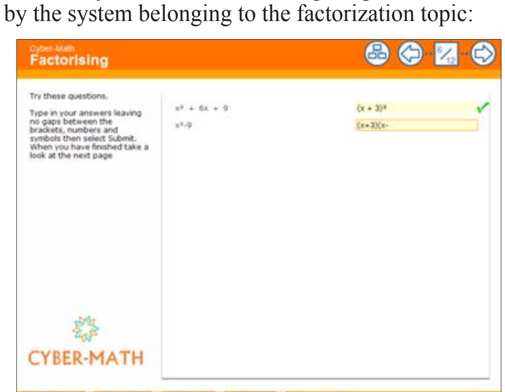


Fig 15: activity fifth

Description of pedagogical experiment

A test was conducted with 60 students of the course "Basic Mathematics" in the "Fundación Universitaria Luis Amigó" in Medellin, Colombia about notable products and quotients. Two groups A and B were created with the same amount of students (30 students). The students of the group A used "Cyber-Math" in their mobile devices (Iphone, Ipad, Smartphone, Tablet) and Laptops, in the group B the students received master classes. The test contained 10 questions and 50 minutes duration. The score were evaluated on a scale from 0.0 to 5.0. The mean ($\bar{X}$) and the Standard Deviation (*S*) of each group are presented below:

$$\bar{X}_A = \frac{\sum_{i=1}^{n} x_i}{n} = 4{,}07 \qquad S_A = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} = 0{,}25$$

$$\bar{X}_B = \frac{\sum_{i=1}^{n} x_i}{n} = 3{,}63 \qquad S_B = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} = 0.35$$

Table 3. Descriptive statistics

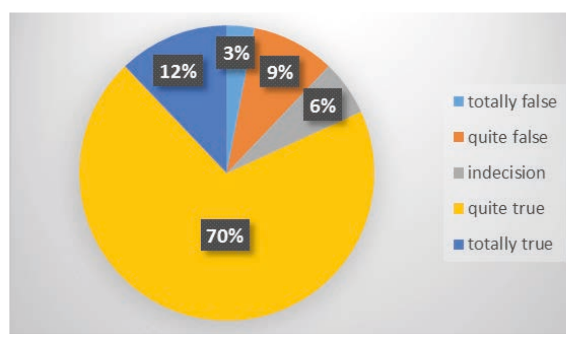
Group A		Group B	
Mean	4,07	Mean	3,63
Typical error		Typical Error	0,06
0,04		Median	3,65
Median	4,0	Mode	3,70
Mode	4,0	Standard Deviation	0,35
Standard Deviation	0,25	Variance	0,12
Variance	0,06	Range	1,4
Range	1.1	Mín	2,8
Mín	3,5	Max	4,2
Max	4,6		

The students of the group A had better scores than students of group B ($\bar{X}_A > \bar{X}_B$). The group B presented greater dispersion ($S_A < S_B$).

Opinions of teachers and students

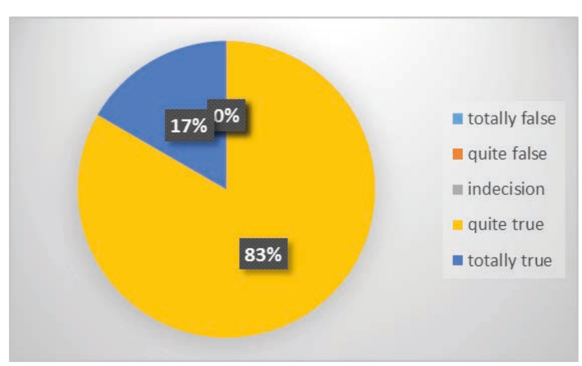
A satisfaction test was conducted to the 30 students who used "Cyber-Math" and the teacher of the course who performed the test (See Annex 1).

1. "*Cyber-Math*" contains enough information about the topic?

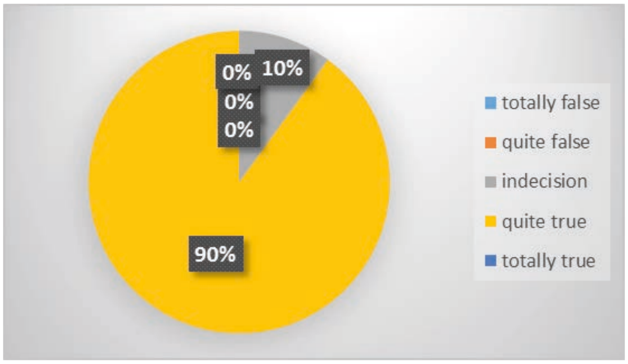


The 70% of students selected the option quite true, 12% totally true, 9% quite false, 6% indecision and 3% totally false.

Q2. The graphical interface of "*Cyber-Math*" is appropriate?

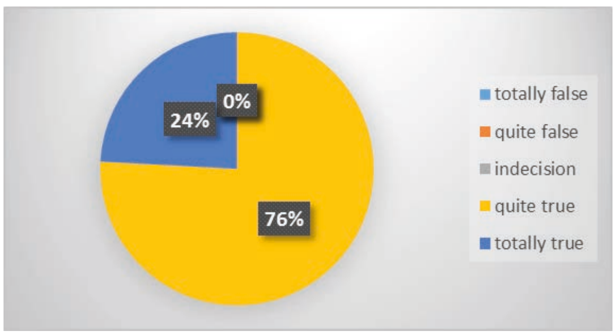


The 83% of students selected the option quite true and 17% totally true.
Q3. The videos and animations of "*Cyber-Math*" are appropriate?

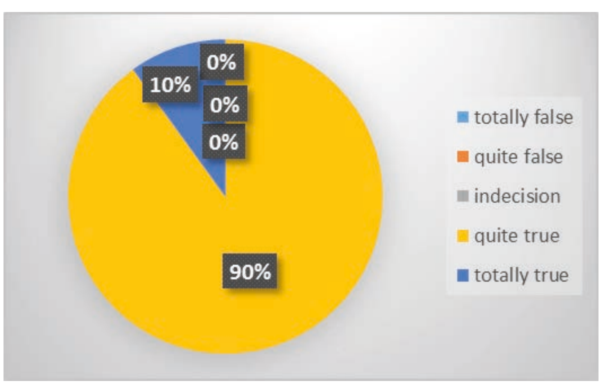


The 90% of students selected the option quite true and 10 % indecision.

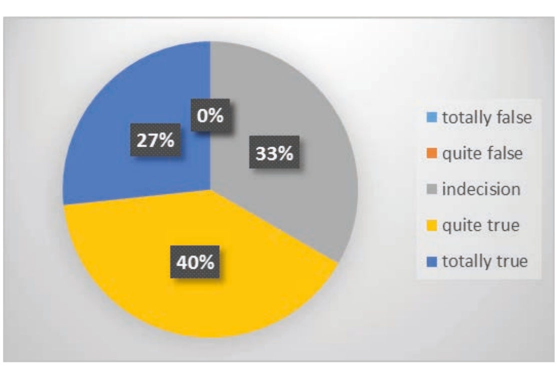
Q4. The graphics of "*Cyber-Math*" are appropriate?



The 76% of students selected the option quite true and 24% totally true.
Q5. The theoretical contents of "*Cyber-Math*" are appropriate?

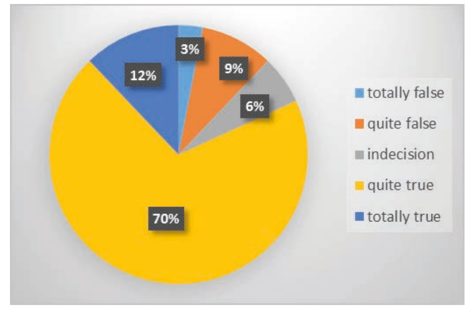


The 90% of students selected the option quite true and 10% totally true.
Q6. The links of "*Cyber-Math*" are appropriate?

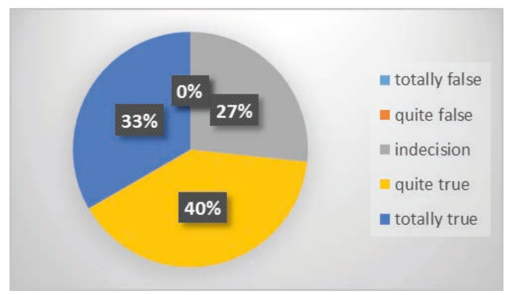


The 40% of students selected the option quite true, 33% indecision and 27 % totally true.

Q7. The proposed activities are consistent with the purpose and contents of "*Cyber-Math*"?

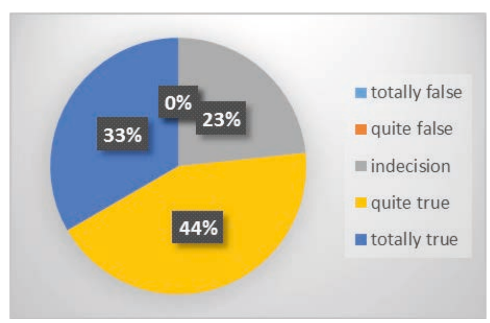


The 70% of students selected the option quite true, 12% totally true, 9% quite false, 6% indecision and 3% totally false.
Q8. The development of the activities allow learning to be consistent with the proposed objectives?

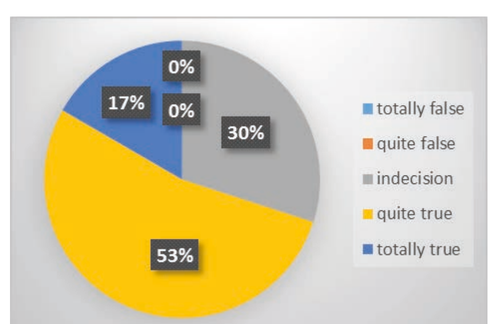


The 40% of students selected the option quite true, 33% totally true and 27% indecision.

Q9. The resources of practice and evaluation allow appropriating the contents of "*Cyber-Math*"?



The 44% of students selected the option quite true, 33% totally true and 23% indecision.
Q10. The use of "*Cyber-Math*" is easy and fun?



The 53% of students selected the option quite true, 30% indecision and 17% totally true.

The majority of students said that they could study with their smart phones and mobile devices without having to go in person where the teacher, the ITS gave them feedbacks that allowed them to identify their errors. They also expressed appreciation for the activities and interactive resources of the ITS.

The teacher of the course said that the students were more attracted and motivated to use "Cyber-Math" than receiving a master class. The integration of ITS with mobile devices allowed students to familiarize more easily with the thematic evaluated. However, some students found it difficult to adopt the ITS and requested personalized advice.

CONCLUSIONS

This paper presents the development of the ITS "Cyber - Math", oriented to the teaching and learning of basic and operational math. It is free and works for mobile devices with access to the internet. A test of validation was conducted with 60 students in the "Fundación Universitaria Luis Amigó", in Medellin, Colombia, 30 students used "Cyber - Math", the other 30 no. The results allowed us to see that the students who used "Cyber-Math" had better results than those that did not.

ITS facilitate the learning process in any area of knowledge, since they have the ability to provide feedback and provide instructions to individual users in real time, without requiring the intervention of an expert human and so allow us to transform the traditional educational model of teaching-learning. Due to the foregoing, the learning of the mathematics can cease to be an arduous and complex task thanks to the great diversity of the aid and technological resources.

BIBLIOGRAPHY

Aguilar, R., Muñoz, V., González, E. J., Noda, M., Bruno, & Moreno, L. Fuzzy and MultiAgent Instructional Planner for an Intelligent Tutorial System. Applied Soft Computing, 11, [2], 2142–2150, 2011.

Aguilar, R., Muñoz, V., Noda, M., Bruno, A., & Moreno, L. Verification and validation of an intelligent tutorial system. Expert Systems with Applications, 35, [3], 677–685, 2008.

Corbett, A., & Koedinger, K. Intelligent Tutoring Systems. In Handbook of Human-Computer Interaction. Elsevier Science B. V, EEUU, 1997, p. 2-5.

Ferreira, A., & Atkinson, J. Designing a feedback component of an intelligent tutoring system for foreign language. Knowledge-Based Systems, 22, [7], 496–501, 2009.

Gutierrez, F., & Atkinson, J. Adaptive feedback selection for intelligent tutoring systems. Expert Systems with Applications, 38, [5], 6146–6152, 2011.

Kalhoro, Q., Chowdhry, L., Abbase, T., & Abbasi, S. M-learning an innovative advancement of ICT in education, IEEE, EEUU, 2010, 2010, p. 148–151.

Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., & Linkman, S. Systematic literature reviews in software engineering – A systematic literature review. Information and Software Technology, 51, [1], 7–15, 2009.

Mitrovic, A., Ohlsson, S., & Barrow, D. K. The effect of positive feedback in a constraint-based intelligent tutoring system. Computers & Education, 60, [1], 264–272. 2013

Murray, T. An overview of intelligent tutoring system authoring tools : Updated Analysis of the State of the Art. In Authoring Tools for Advanced Technology Learning Environments, Springer, Netherlands, 2003, p. 493–546.

Nkambou, R., Bourdeau, J., & Mizoguchi, R. Advances in Intelligent Tutoring Systems. Berlin, Heidelberg: Springer, Germany, 2010, p.42-51.

Sanchez, R. P., Bartel, C. M., Brown, E., & DeRosier, M. The acceptability and efficacy of an intelligent social tutoring system. Computers & Education, 78, [1], 321–332, 2014.

Staples, M., & Niazi, M. Experiences using systematic review guidelines. Journal of Systems and Software, 80, [9], 1425–1437, 2007.

Xerte. (2015). Xerte Community. M-Learning. Retrieved from http://xerte.org.uk/index.php?lang=es&Itemid=642. Access [Jan 12 2016]

ANNEX 1

The following 10 items are to evaluate their level of satisfaction with the use of "Cyber-Math". Select one of the 5 response options:

1 totally false
2 quite false
3 indecision
4 quite true
5 totally true

Q1. "*Cyber-Math*" contains enough information about the topic?
Q2. The graphical interface of "*Cyber-Math"* is appropriate?
Q3. The videos and animations of "*Cyber-Math*" are appropriate?
Q4. The graphics of "*Cyber-Math*" are appropriate?
Q5. The theoretical content of "*Cyber-Math*" are appropriate?
Q6. The links of "*Cyber-Math*" are appropriate?
Q7. The proposed activities are consistent with the purpose and contents of "*Cyber-Math*"?
Q8. The development of the activities allow learning to be consistent with the proposed objectives?
Q9. The resources of practice and evaluation allow appropriating the contents of "*Cyber-Math*"?
Q10. The use of "*Cyber-Math*" is easy and fun?

Received 2-10-2016 /Approved 15-05-2017

Aplicación de un aprendizaje basado en problemas en estudiantes universitarios de ingeniería del riego

Application of a problem-based learning in university students of irrigation engineering

César A. Rodríguez, José M. Fernández-Batanero

Escuela Técnica Superior de Ingeniería, Universidad de Huelva, Facultad de Ciencias de la Educación, Universidad de Sevilla, España, batanero@us.es, cesar@uhu.es

Resumen

En el presente artículo se presentan los resultados de un estudio realizado mediante la metodología activa de aprendizaje denominada "Aprendizaje basado en Problemas" (ABP), en estudiantes universitarios. El trabajo se ha desarrollado durante el curso 2015-16 en dos grupos de alumnos de la asignatura Ingeniería del Riego, en el Grado en Ingeniería Agrícola de la Escuela Técnica Superior de Ingeniería de la Universidad de Huelva (España). Ha comprendido la aplicación de la metodología didáctica específica y su evaluación, detallándose el problema estructurante diseñado y su división en subproblemas. La evaluación se ha efectuado empleando un método cuasi-experimental. Entre las conclusiones se destaca que el ABP es preferible a la metodología tradicional expositiva, al resultar significativa la diferencia en adquisición de conocimientos por los estudiantes. Así mismo, se produce mejora en los planteamientos para la resolución de los problemas planteados, no sólo la diferencia en resultados numéricos finales, sino el planteamiento establecido para llegar a los mismos.

Palabras clave: *aprendizaje basado en problemas, formación de ingenieros, método cuasiexperimental, ingeniería del riego*

Abstract

In this paper results are shown for research carried out through active learning methodology, which is called "Problem-Based Learning" (PBL), among university students. The work was developed during the academic year 2015-16 and it