

IMPLEMENTATION OF AN INTELLIGENT TUTORIAL SYSTEM FOR SOCIOENVIRONMENTAL MANAGEMENT PROJECTS

Gil Vera, Víctor Daniel¹ and Awad, Gabriel²

¹*Fundación Universitaria Luis Amigó – Sede Medellín*

²*Universidad Nacional de Colombia – Sede Medellín*

ABSTRACT

The agents responsible of execution of physical infrastructure projects of the Government of Antioquia must know the theories and concepts related to the socio-environmental management of physical infrastructure projects. In the absence of tools and the little information on the subject, it is necessary to build a m-learning tool to facilitate to public functionaries, contractors and communities assimilate the knowledge and contribute to generate the minimum environmental impacts on the environment. The objective of this paper is to present MGSAT Tutorial System, designed to support the learning process and appropriation of knowledge to public functionaries, contractors and communities. This work is divided in three parts; in the first, it presents the results of the review of the state of the art; in the second, the methodology used in the construction of the intelligent tutorial system (ITS), in the third part explains MGSAT tutorial Expert System as a case of application.

KEYWORDS

M-Learning, infrastructure projects, socioenvironmental management, intelligent tutoring systems.

1. INTRODUCTION

Intelligent Tutorial Systems (ITS), as a branch of applied artificial intelligence (AI), are applications for computers whose main objective is to simulate the process of teaching of a human-tutor, both in the domain of a specific theme as in the aspects related to pedagogy and communication with the user. ITSs are designed to guide the learning process for a user in an area of knowledge at any time and place, without the need to interact directly with an expert.

The Government of Antioquia executes many physical infrastructure projects that require the domain and knowledge of concepts and theories on which the activities are founded. Considering the large number of concepts and theories related to the socio-environmental management of infrastructure projects that public functionaries, contractors and communities need to know MGSAT Tutorial System is built.

MGSAT Tutorial System is one of the results of the research project “Socioenvironmental Management Manual of Infrastructure Projects” (MGSAT), which stems from the idea that the physical infrastructure projects contribute to the development of the regions. Due to the importance of this class of projects, it raises the need to build an application for mobile devices such as mobile phones, PDAs, tablets, PocketPC, iPod and other handheld devices that have some form of wireless connectivity, which facilitates the process of teaching and learning to the agents involved in the development of physical infrastructure projects.

MGSAT Tutorial System was designed to facilitate the teaching and learning process in four main themes: management, licenses, studies and socio-environmental impacts. In each thematic presents the theories and concepts, accompanied by activities and interactive resources that facilitate the learning, understanding and memorization of the user, giving you the option to access the application at any time and place.

This work is divided in three parts; in the first, we present the results of the review of the state of the art; in the second, the methodology used in the construction of the intelligent tutorial system (ITS), in the third part explains MGSAT tutorial Expert System as a case of application.

2. INTELLIGENT TUTORING SYSTEMS

Intelligent Tutoring Systems were first used in the 70s as a way to provide greater flexibility to the learning strategy and to achieve better interaction with the user (Aguilar et al. 2011). The aim of ITS is to capture the knowledge of experts to create dynamic interactions with the users, allowing them to make decisions, even those that may not have been anticipated by the experts (Aguilar et al. 2011).

Intelligent Tutoring Systems are computer-based instructional systems with models of instructional content that specify what to teach, and teaching strategies that specify how to teach (Murray 2003). They make inferences about a student's mastery of topics or tasks in order to dynamically adapt the content or style of instruction. Content models give ITSs depth so that students can "learn by doing" in realistic and meaningful contexts. Models allow for content to be generated in real time. ITSs allow "mixed-initiative" tutorial interactions, where students can ask questions and have more control over their learning. Instructional models allow the computer tutor to more closely approach the benefits of individualized instruction by a competent pedagogue (Murray 2003).

The main advantage of ITS versus traditional tutoring systems is that they are more flexible in both their approach to the learning domain as well as in their adaptation to the student. In traditional systems, which contain a large amount of rules, and therefore of information, the student can find herself lost and improperly guided by the tutorial (Aguilar et al. 2011).

The design of Intelligent Tutorial Systems is founded on two fundamental assumptions about learning (Ferreira & Atkinson 2009). First, individualized instruction by a competent tutor is far superior to the classroom style because both the content and the style of the instruction can be continuously adapted to best meet the needs of the situation. Secondly, students learn better in situations which more closely approximate the situations in which they will use their knowledge, i.e. they learn by doing, by making mistakes, and by constructing knowledge in a very individualized way (Ferreira & Atkinson 2009). The design of an ITS can focus on various issues, including the tutoring decisions which take place in the tutoring module and the facts and rules represented in the expert module (Ramesh & Rao 2012).

In brief, Intelligent Tutoring Systems for mobile devices have the potential to introduce advancements in the area of learning and education. The essential concept of mobile learning is to have m-learning facility anywhere and anytime (Kalhor et al. 2010).

2.1 M-Learning Applications for Socio environmental Management Projects: Related Works

The basis of this section is present the search method of literature reviews, conference proceedings, state of the art, articles and journals. The section offers a survey of socio-environmental mobile learning projects based on a systematic review of publications from: MLearn 2012, 2013, 2014.

We also reviewed the papers from the following journals: *Journal of Computer Assisted Learning* (JCAL), *Computers and Education*, *Journal of the learning science*, *International Journal of Mobile Learning and Organisation*, *International Journal of Computer-Supported, Collaborative Learning* and the *International Journal of Learning Technology*.

We started with the review of journal articles in the year 2009. We scanned 110 papers of MLearn conferences and 15 papers of journals. The search included the key words: m-learning, mobile learning, infrastructure, projects, socioenvironmental management. In sum, we scanned 125 papers. The equations of search used were:

- (1) **(TITLE-ABS-KEY (m-learning) OR (mobile learning) AND (((projects) OR (infrastructure)) OR (((management) OR (social) OR (environmental))))**
- (2) **(TITLE-ABS-KEY (m-learning) AND (mobile learning) AND (((projects) AND (infrastructure)) AND (((management) AND (social) AND (environmental))))**
- (3) **(TITLE-ABS-KEY (mobile learning) AND (((projects) AND (infrastructure)) OR (((management) AND (social) OR (environmental))))**

(4) (TITLE-ABS-KEY (m-learning) AND (((projects) AND (infrastructure)) AND (((management) AND ((social) OR (environmental))))

(5) (TITLE-ABS-KEY (mobile learning) OR (((projects) OR (infrastructure)) OR (((management) OR ((social) AND (environmental))))

The any related publication found in the review was developed by Attwell (2010). This developed an application to contribute to a socio-cultural ecology for learning, and the interplay of agency, cultural practices, and structures within mobile work-based learning. In sum, we can say that the development of this work is addressing an issue that has not been treated with m-learning.

2.2 Relationship of MGSAT Tutorial System with M-Learning

MGSAT Tutorial System is a learning tool for socio-environmental management of physical infrastructure projects. It is based on the methodology of teaching and learning with the use of mobile devices that have some form of wireless connectivity. Mobile learning is defined as learning across multiple contexts, through social and content interactions, using personal electronic devices (Crompton, 2013).

The mobile learning developed in this work is a form of e-learning distance education, where public functionaries, contractors and communities can use mobile device educational technology in many locations at their time convenience for to learn the large number of concepts and theories related to the socio-environmental management of infrastructure projects. In brief, m-Learning applications for mobile devices have the potential to introduce advancements in the area of learning and education in sociocultural management projects. The essential concept of mobile learning is to have m-Learning facility anywhere and anytime (Kalhor et al. 2010).

The three standard factors for mobile learners are: the learner (subject), the learning goal (objective) and the tools that are used to mediate the learning goals to the learner (Frohberg, Göth, & Schwabe, 2009). Figure 1 presents the task model for mobile learners.

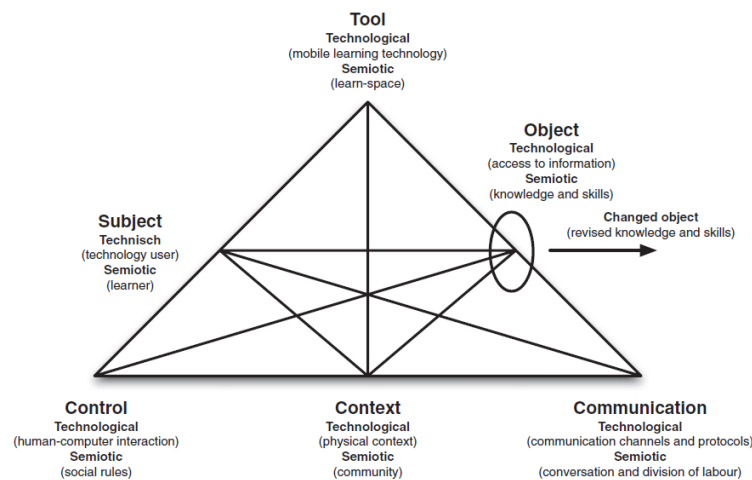


Figure 1. Task model. Source: Taylor et al. 2006; Sharples et al. 2007b

Taylor, Sharples, & Malley (2009), defined the others components of the task model for mobile learners:

- **Control:** The putting learners in control of their learning is one of the much vaunted benefits of technology enhanced learning. To a certain extent this is a technological benefit which derives from the way in which learning is delivered – if the learners can access materials as

and when convenient, they can work through the materials at their own speed, revising and re-checking as they wish (Taylor et al., 2009)

- **Context:** The context in which learning takes place is clearly a significant factor, but the term has many connotations for different theorists. In the Task Model, we aim to pin down two important aspects of context – the physically embodied technological context, and the human, semiotic context within which learning takes place (Taylor et al., 2009).
- **Communication:** The dialectical relationship between the technological and semiotic worlds is perhaps the easiest to see in the Communication node, if the system enables certain forms of communication, learners can adapt their communication behaviour accordingly, and sometimes find ways to subvert the technology (Taylor et al., 2009).

3. METHODOLOGY

For the construction of MGSAT Tutorial System was conducted a systematic literature review. A systematic literature review (SLR) is a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest. Individual studies contributing to a systematic review are called primary studies; a systematic review is a form a secondary study (Kitchenham 2004). In other words, is a defined and methodical way of identifying, assessing, and analysing published primary studies in order to investigate a specific research question (Staples & Niazi 2007).

Kitchenham (2004) describes the three main phases of a systematic review process: planning the review, conducting the review, and reporting the review. Each of these phases contains a sequence of stages, but the execution of the overall process involves iteration, feedback, and refinement of the defined process (Staples & Niazi 2007):

- **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.
- **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 main advantages and disadvantages of a Systematic Literature Review are: SLR requires considerably more effort than traditional reviews. Their major advantage is that they provide information about the effects of some phenomenon across a wide range of settings and empirical methods. If studies give consistent results, systematic reviews provide evidence that the phenomenon is robust and transferable. If the studies give inconsistent results, sources of variation can be studied (Kitchenham 2004). A second advantage, in the case of quantitative studies, is that it is possible to combine data using meta-analytic techniques. This increases the likelihood of detecting real effects that individual smaller studies are unable to detect. However, increased power can also be a disadvantage, since it is possible to detect small biases as well as true effects (Kitchenham 2004).

For the construction of the tutorial system was conducted a systematic literature review on the scientific database Scopus on two main themes: intelligent tutorial systems and socio-environmental management of infrastructure projects. The search words used were: m-learning, infrastructure projects, socioenvironmental management. The equation of search used was:

(6) **(TITLE-ABS-KEY (m-learning) OR (mobile learning) AND ((projects) AND (infrastructure)) OR ((management) AND (social) OR (environmental)))**

The range of dates of publication considered in the review of the state of the art was from 2008 until the present. In total four publications were collected between articles, conference articles, abstracts, book chapters and articles in press. In the review was collected 1 article and 3 Conference

articles. The year 2014 was presented the largest amount of publications on the topic, with a total of 2. To perform the same analysis for the authors, *Madjarov, I.*, is who has the largest number of publications, with one in total and the journal with the largest number of publications is *Information Technology for Development*.

As a result of the search for grey literature was compiled books sections and manuals on socio-environmental management of infrastructure projects, published by the Roads National Institute (INVIAS), the Area Metropolitana del Valle de Aburrá and the Mayorality of Medellín, which were used in the construction of MGSAT Tutorial System. In addition, a review was conducted of the environmental regulations in force for Colombia, identifying the most important issues to be considered in each thematic of tutorial system. Table 1 presents the main results of the search of normativity classified by type:

Table 1. Normativity. Source: Autor Development

Norma type	Total
1991 Political Constitution Articles	15
Laws	20
Decrees	29
Resolutions	26
CONPES	20
Environmet Guides	6
Court Constitucional Judgments	10
Total	126

Furthermore, there were reunions and interviews with functionaries of the Physical Infrastructure Secretary of Antioquia (SIF) between September 2013 and June 2014, with the objective of conceptualizing the most relevant aspects of the environmental management infrastructure projects. All the gathered information was used for the design and implementation of the intelligent tutorial system ITS ending with the testing. MGSAT Tutorial System is still in the phase of construction and development, by which is subject to future modifications and improvements.

MGSAT Tutorial System, presents the basic concepts of socio-environmental management of infrastructure projects in the form of question/answer. Then, presents activities and interactivity resources that seek to assess the level of understanding, assimilation and memorization of the user, such as fill in black, multiple-choice question, feedback, button sequence, quiz, timeline, matching pairs, animations, etc. The other thematic areas of the system are: licenses, studies and socio-environmental impacts. Finally, there are videos and other multimedia resources that present the main environmental problems that are presented in the world. For the construction of MGSAT Tutorial System were considered different points of view of specialist teachers in environmental management, identifying for each thematic axis the information that would be of interest to the user.

MGSAT Tutorial System is constructed using the XERTE software (Xerte 2014c). This software provides a full suite of open source tools for e-learning developers and content authors producing interactive learning materials (Xerte 2014a). XERTE is a fully-featured e-learning development environment for creating rich interactivity. XERTE is aimed at developers of interactive content who will create sophisticated content with some scripting. Among the various applications that can be performed with the software highlights the belonging to the field of medicine, the statistical and problem-based learning (PBL) (Xerte 2014b). The phases of the creation of MGSAT Tutorial System were acquisition and representation of knowledge.

The information used in the construction of MGSAT Tutorial System was obtained from specialized publications in scientific data bases and grey literature of socio-environmental management of infrastructure projects. In addition, interviews and meetings with functionaries of the Physical Infrastructure Secretary of Antioquia (SIF). The thematic axes of the systems are environmental management, licenses, studies and socio environmental impacts. Firstly, the user select the thematic axis; environmental management, licenses, studies or environmental impacts, which are mutually exclusive. Next, the system presents the concepts, theories and the activities that seek to assess the level of understanding, assimilation and memorization of the user. Finally, the system presents the option to return to the main menu or exit of the system.

- **Verification:** built the structure of the model, it is proceeded to verify that each activity presented by the system were correct according to the information of the knowledge base. For this, tests were performed with interested people, facilitating the identification of conflicts and problems presented by the system for later correction.
- **Validation:** a preliminary validation of the tutorial system was conducted by teachers specialized in socio-environmental management of the National University of Colombia - Medellin. At this stage they were allowed to explore their operation and make suggestions for changes in the design of content and the interface.

3.1 MGSAT Tutorial System Validation

In order to validate the effectiveness of MGSAT Tutorial System, a comparative test will be conducted with 30 university students from different programs randomly assigned to two groups of the same size. The first group will use the tutorial system, while the second will receive a text document that contains the crucial topics on socio-environmental management projects. After that, each participant will answer a knowledge test about the subject under study. The results of the test will allow us to validate the effectiveness of MGSAT Tutorial System, and after that we will make some improvements to the tool.

4. APPLICATION CASE

Due to the great diversity of physical infrastructure projects that develops the Physical Infrastructure Secretary of Antioquia, was built MGSAT Tutorial System, whose main objective is to support the process of learning and assimilation of concepts and theories related to the socio-environmental management of projects. The thematic axes of the system are socio-environmental management, licenses, studies and socio environmental impacts. To begin, the user selects the theme you want to know: basic notions, licenses, studies or socio-environmental impacts. Next, the system presents a series of activities that seek to assess the level of understanding, assimilation and memorization of users, accompanying and feeding back to the user in real time. At the end of each thematic axis, the system presents the option of return to main menu or exit the system.

4.1 What are the Main Elements of the MGSAT Tutorial System?

Knowledge Base (BC): Gathers all the information about the basic concepts of socio-environmental management, licenses, studies and socio-environmental impacts. Figure 2 presents an example of the type of information present in each thematic axis:

<u>Management</u>	<u>Licenses</u>	<u>Studies</u>	<u>Impacts</u>
What is the socio-environmental management?	What are the environmental licenses?	What are the environmental studies?	What are the environmental impacts?
What is the object?	How can I apply for?	What are they used for?	What types are there?
What are the principles?	In what cases are required?	In what cases are required?	How can I apply for ?

Figure 2. Thematic Axis. Source: Autor

4.2 How Does it Work MGSai Tutorial System?

To execute MGSai Tutorial System, the user must enter to the next link: <http://mgsai.net63.net> It is necessary to have installed on your mobile device the 11.1 version of Adobe Flash Player. The user progresses with the buttons or navigation arrows available at the top of the system. Figure 3 presents the second interface of the system, which specifies the objectives, the audience and how to use it.

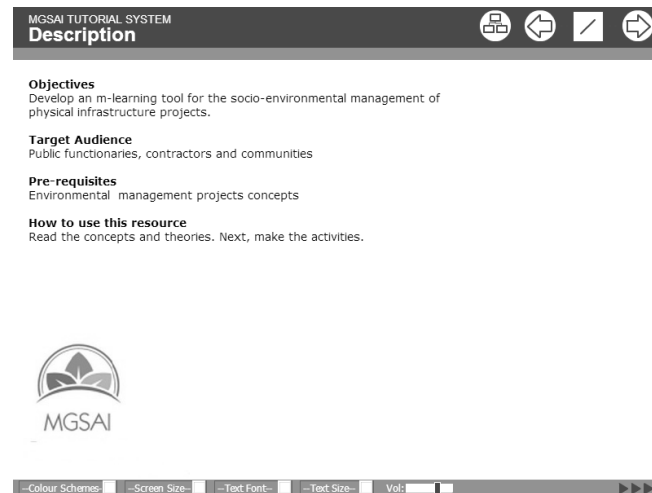


Figure 3. Second Interface. Source: Autor Development

Figure 4 presents the first activity of the environmental licenses thematic axis. Each thematic axis has five activities; multiple choice question, gap fill, quiz, timeline, button sequence.

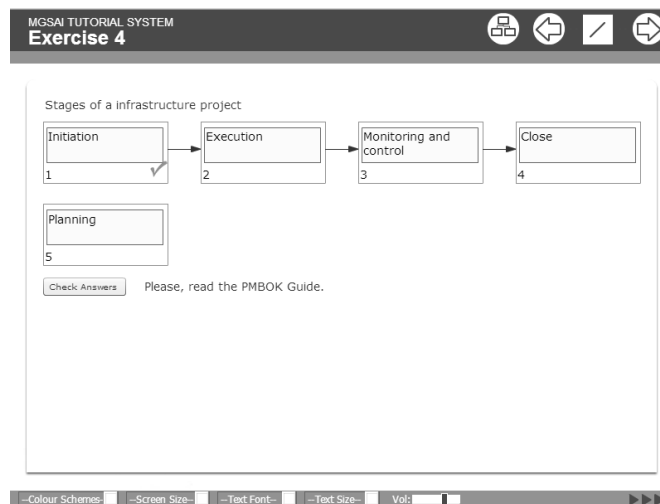


Figure 4. Activity 1. Source: Autor Development

5. CONCLUSIONS

The Intelligent Tutoring Systems applied to socio environmental management of infrastructure projects facilitate the learning process of concepts and theories to public functionaries, contractors and communities. The ITSs have the ability to provide individualized instructions or feedback to users without the intervention of human-tutor. The key feature of ITSs is the ability to adapt presentation of

teaching materials to a particular student by using methods of artificial intelligence (AI) to make pedagogical decisions and to represent information about each user.

m-Learning is a different pedagogical approach and opens diverse dimensions of effective learning in the student to student, student to teacher and teacher to student scenarios. It allows flexible learning by being at a distant place but still being a part of the classroom activity.

The main expected benefits of MGSAI Tutorial System are the learner engagement, the collaborative learning and the easy access. The main limitations are the display and some connectivity problems.

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