SA³C - Platform of Evaluation System and Computer Assisted Learning

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Abstract: - The Mathematics Education Project (PmatE) has developed and continued to develop a set of tools that present an innovative perspective about traditional applications of e-learning – play and constant challenge components that attract students to studying practices. This article intends to provide a general view of how this Project has been developed in the previous two years.

Key-Words: - e-Learning, e-Tutoring, Computer Mediated Learning, Information Systems.

1 Introduction

The first steps of this Project were taken in 1989/90, but the platform of the Evaluation System and Computer Assisted Learning (SA³C), in its developing stage, demanded a profound adaptation in order to meet the ongoing challenges of new technologies of information and communication. This task was initiated in the year 2002. Fostering pleasure in mathematics learning, namely for school mathematics, continued to be an objective and essential philosophy of the project. Equally important is the second objective which aims at using these tools as teaching and evaluation instruments. Students from several levels of education, ranging from Elementary to Higher Education Schools are involved in the project; each educational program presents different levels of development. The contents are subjected to an intense modulation work done by members of the PmatE team and by the teachers of the correspondent grades. The models which generate questions [1], designated from now on, as models for a study-approach in the next section, are didactic objects that generate questions based upon scientific and learning objectives. Models may be organized in a competition mode or as an evaluation and learning system. Modularity, flexibility and at randomness are fundamental features of the products PmatE, and such features are important to promote a constant interest in the product.

In the competition mode, a collaborative competition is suggested. In the learning and evaluation mode the cooperation among schoolmates and teacher is an intrinsic aspect of the process. The questions generated by the models are of the true-false generalized type, concept which will be thoroughly explained further on. The system contains several mechanisms, some internal, some external, to minimize at random answers. The tests associated to each question have specific objectives; concepts, basic applications of those concepts, and whenever possible, graphic interpretations are tested. This multiple approach increases the comprehension of the concepts.

Due to a program of associated data analysis, the student can control the degree of knowledge acquisition (auto diagnosis) and the teacher can diagnose the learning of his or her students as well as follow the students’ learning process until a certain stage. This is not intended to be the only form of evaluating students, a complementary evaluation involving writing and calculation competences must also take place.

The experiences and tests implemented mainly with the EQUAmat program are very promising, after fourteen years, our enthusiasm in the project is still
vivid. In the higher levels of education, where modulation difficulties and computer tasks are more intense, experiences implemented in several subjects - Numerical Methods, Mathematical Foundations, Topics in Mathematics, Calculus I and Calculus II – have also revealed the enormous potential of the program in the learning process and its contribution to decisively increase the involvement of the students throughout the semester.

2 E-Learning and Computer Assisted Education

Defining e-Learning does not seem simple [2]. The principal problem resides in finding an accurate meaning for the prefix “e”. Some believe it stands for electronic education, some defend it refers to education based exclusively on the Internet, others think e-learning is somewhat related to the use of technologies such as audio cassettes, CDs, DVDs, and Internet. The key difference in these teaching paradigms resides mostly on the teaching methods and not on the technologies involved in such process.

In our point of view Computer Assisted Teaching/Education is a subdivision of e-Learning. Although both may use the same technology, in Computer Assisted Teaching/Education the spatial and time barrier between teacher and student may not exist, in fact it should even be strengthened. As far as E-Learning is concerned, learning control (contents selection, studying timetables and intensity) is mostly done by students, so they should be old and mature enough to control the self-learning process.

At distance education, with the internet as a base, has several advantages [3]: Flexibility, access and convenience: users may access the program at any time and any place. Multi-platform: the use of HTML and other technologies allows the access to contents in various platforms: windows, unix, mac, linux, among others. Availability: Internet is cheaper and more widespread.

Easy and Cheap Distribution: from the point of view of the contents producer, distribution tends to be easier, for no other means of distribution is necessary. Easy Updating: if the program needs to be updated, all that is necessary is to alter the version in the server and the alterations will immediately become available for all users. Some disadvantages presented by Brandon Hall in [3], are: Limitations to the bandwidth: a short bandwidth means an unpleasant and a slow distribution of multimedia contents to the user. Bandwidth links are a relative recent reality. Lack of human contact: a general concern that computers are more and more present in every aspect of human life. Unchangeable contents: like any new technology, electronic contents in education do not yet have the desired and expected interactivity. The development of contents is more expensive and time-consuming than expected: the use of sophisticated technology requests huge initial investments, despite the low costs of distributions. Besides these disadvantages, we may also add another two very important drawbacks: low density of information and short periods of concentration [4].

The amount of information that may be presented on a computer screen is limited when compared to printed material. On the other hand, several studies have shown loss of concentration and perception when large quantities of information are obtained on a computer screen [4, 5].

3 SA^3C – from the model to the final application

The SA^3C has its own philosophy, as a product it can be based on the knowledge evaluation applications. Its main focus of application is learning through evaluation, being constant challenge one of its strongest elements of motivation.

3.1 The Model

The atomic unity of the system of information is the concept of question generator model (from now on designated as model) [1]. It is precisely this concept
of model that is responsible for two of the most important features of SA3C: flexibility and modularity. We have chosen multiple response/answer questions of the type True-False-Generalized [1], which means the user is always confronted with a set of propositions to which the response can only be true or false. Because they are of the type True-False-Generalized, all the responses may be false or true or both in an at random manner. Opposed to the majority of the tools that exist in this area, SA3C has the capacity to present the user a different approach of each question. This is possible, because instead of storing static questions in a database, question generators are stored. The question generator is the model.

An accomplishment of the model will result in an enunciation which is always composed of a common text + a set of four items taken at random from k, with \( k \geq 4 \). The text with an item results in a proposition. The options of “response” included in the model are normally related to the most common errors committed by students, but they are also a result of the concept we intend to evaluate and of the prerequisites of the concept.

In order to minimize at random responses, the model contains a system that allows increasing the formulation hypothesis of the possible enunciations. This system has been designated as a box diagram. This system presents wider dynamism to the questions presented and as a consequence, it increases the levels of concentration of the students. Another advantage of its use is the balance between false and true patterns. Once the model is constructed we then proceed to the phase of validation of assertions.

The validation consists in indicating the conditions in which a certain formal assertion becomes true. These conditions depend on the parameters, the signs and on the expressions generated.

### 3.2 Language of Model Representations

The complexity of the models demand that the transcription process to the computer system follow very clear criteria so as to minimize process errors. Furthermore, all members of the model transcription team should be able to easily understand the logic line-up of the computer code of the model.

So as to establish a set of elementary rules of programming, a Language of Model Representation has been developed (LRM) [6, 7]. This language has been developed based on many LATEX concepts for it is very familiar to the scientific community and especially to mathematicians. The models are transcript from paper to LRM and stored on the data base. In order to interpreter LRM language, a LRM processor was developed. LRM uses a set of symbols with different functions for representation and concretization.

The LRM processor interpreters past instructions and then, if necessary, converts the final expression in MathML.

This system enables the model program team not only to be able to develop intense work but also to achieve high levels of coherence in the programming style. Therefore a same model can be both programmed and revised by various people.

### 3.3 Codification of Models

When introduced in the system, all models are coded according to a structure of the type:

![Figure 1 Structure of the Model Codes](image)

The system contains a multidimensional tree with the structure presented on figure 1. The models are carefully positioned in this tree of objectives. Each one of the responses associated to the model is coded according to a similar structure, although in this case there is still some more information. Each answer can, in the context of the model, have a particular objective, so it is possible to associate more than one objective to each answer/response.
The various objectives must remain related to the objective of the question. The objective of the model remains automatically associated to the answer/response.

Figure 2: Structure of response objectives codes
The coding of responses is based on the same tree of model objectives. So we are certain that there is always a point that links any response to a set of models and not exclusively to the model to which the response refers to.

The coding of the tree of objectives is according to the American Mathematical Society thesaurus as well as the INSPEC of IEE (Institution of Electrical Engineers) [8, 9].

4 Technologies Applied
In terms of Hardware the system has been divided according to the logic division of services:
- Server dedicated to the management system of the data base.
- Web Server and application logic.
- Application Server to perform advanced calculations. (WebMathematica)

The solution was to build a core of servers, distributing several services through three machines (according to Figure 3). This system architecture allows us to create mechanisms of redundancy at the application level and it predicts its development: any of the three servers can be replicated if necessary.

The platform is constituted by a machine containing an IIS server and a DCOM application, developed for model processing. A second server maintains the management system of the data base, presented in the figure as Rantanplan. The third machine contains a Servlets/JSP server, webMathematica and a local sever e o server DNS (Domain Name Server). The machines communicate amongst themselves through a local net available exclusively to allow communications among services; therefore traffic generated by communications among services is optimized. The first server is the access way to the various applications of SA³C.

Figure 3: Hardware Architecture
As far as software is concerned, the development platform of the chosen application was the classical Microsoft platform: WISA [10].

4.1 Representation Technologies
In order to represent data on the client side various technologies are used. As language of document definition and for hyperlinks specification we follow HTML. For the representation of mathematic text we follow MathML and for two dimensional drawings of vector graphics we use SVG. SVG, Scalable Vector Graphics, allows us to define graphics with different effects, textures, animation, scripts and zooms. The objects can be vectors, images or blocks of texts. The vector graphics can be: lines, curves, circles, rectangles and polygons, etc..

Considering the high degree of at randomness, the system should be able to represent a mathematic formula in any part of the screen in an unknown
number of times. That is to say, it should be possible to have a variable amount of mathematical text spread around the screen randomly. Besides this, figure representations with high quality and real time approaches would also be possible.

4.2 Dynamic representation of Mathematical Expressions

The World Wide Web Consortium (W3C) has developed a new technology based on XML the MathML. The use of MathML language is possible at the moment by means of the use of transformation technologies on XSL documents - using Mozzila, FireFox and Amaya browsers - or by means of the utilization of visualization components – using the Internet Explorer. MathPlayer by Design Science was the chosen to be the visualization component.

The most universal form - because it does not demand the installation of any component – for the interpretation of MathML is the use of inline MathML in XHTML documents. Further on we apply the capacity of transformation in the client resorting to files XSLT which W3C has supplied. The mechanism is in all ways similar to the transformation of documents XML using XSL.

In general, the results obtained are satisfactory, however they are insufficient for the level of quality we would expect to achieve. There are several minor aspects that do not allow the use of this method. The graphic quality does not compare to that of MathPlayer, as we can see in figure 4.

Due to the high degree of at randomness in the documents presented to the client- because the associated parameters to each question generator model are constantly being altered – each time it is altered in the server, the client application must load a new page, which is not always the case with XML.

![Figure 4: Comparison of final results using MathPlayer and XSLT](image)

4.3 Dynamic Representation of Figures

Another limitation of the browsers is the dynamic representation of figures. Our needs consist in having an application that may represent simultaneously a bar-graphic, a circular graphic or a mathematic function.

Building a new graphic representation would be unbearable, so the solution would be to find an application that would build a library of objects reusing them in more complex figures.

At first we considered using Macromedia Flash.. This approach is not suitable because it would require huge effort in its development, so it was considered unsuitable. SVG is the alternative format to Flash for the drawing of graphic vectors.

SVG is a vector format, which means the objects are conceived through vectors and they do not lose quality in the redimensionlization process.

Just as MathML, SVG is a standard recommended by W3C and it is capable of excellent results, it is also an extension of XML language, which results in high development stages and an easy format to edit in any text editor. Because it is not a format which is directly supported by the most browsers, it requires a visualization component. Adobe Corporation has developed a visualization component, the SVGViewer.

5 Conclusions

This project was initiated around the time of the update of the system of information of Mathematics Education Project. We now present some of the conclusions drawn from the implementation of the project.

We may conclude that the focus on true-false generalized type response along with the box diagram – which introduces a high level of at randomness to the generated question – may decrease at random responses. If we add to these mechanisms some attention to the way the contents are modeled, we are taking an important step ahead as far as traditional true-false questions are concerned.

All of this has contributed to increase the degree of concentration of the students and their comprehension of the texts presented to them.
It is not our intention to resolve adjacent problems of free response, the reality is that the philosophy that presides in the application allows an approximation of results that this type of questions allows. These principles can also be efficiently used as a complement to these types of problems. In this context the application developed was used in various subjects, at first in plot classes as in Mathematic Topics and later on in subjects such as Calculus I e II. In these subjects, the system was used naturally as a means of study, but also as a means to obtain a passport for the final written exam. As a result of its use, we noticed that the students started preparing and studying earlier than usual and the passport denied access to the students which did not prepare for the exam.

The simplicity of the interaction with the software has also resulted in a positive sense; no sort of difficulty was posed to the user; not to those belonging to age groups 8 and 9 years of age, neither for adults. The choice of technology to solve several problems of representation was also positive. The use of MathML and SVG allowed the resolution of most problems of representation put forward by the models.

References


