THE USE OF INTERACTIVE INSTRUCTORS OF RECREATIONAL MATHEMATICS IN SECONDARY SCHOOLS

Gabriel López-Morteo
Universidad Autónoma de Baja California, Calle de la Normal y Benito Juárez, 21280, Mexicali, B.C., México

Marcos Galaviz-Férman, Gilberto López
CICESE, Km. 107 Carretera Tijuana-Ensenada, 22860, Ensenada, B.C., México

M. Andrade-Aréchiga
Universidad de Colima, Av. Universidad 333, 28040, Colima, Col, México

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Abstract: A methodology for secondary math teachers, designed to introduce information technology through Interactive Instructors of Recreational Mathematics (IIRM) and an electronic ludic learning environment in its practice, is studied. First, an instrument designed to find the level of knowledge of the teachers in information technologies was applied. We show the preliminary results of applying this device in 20 secondary schools of the region, which allowed us to choose three different representative scenarios, to make the case of study. As a result of the observations and interviews that were made, we show the form in which the teachers obtained a greater degree of interaction and participation from the students in the particular subjects that were taught. It allowed them to identify different levels of abilities and different learning progress among the students. Another important result of the investigation is the stable and reliable answer of the learning environment in realistic scenarios.

1 INTRODUCTION

In recent years, the ludic approach for teaching mathematics supported by information technology, has acquired relevance due to its capability of engage students towards mathematics learning. Some of the different approaches used electronic learning environments (Sanchéz, 1998) and computers games (Gorriz and Medina, 2000; Gros, 2002). However, according with (Wishart, 2000), the introduction of new technology for learning requires the development of a learning environment founded on solid learning models.

In México, most of the public secondary schools have at least one computer laboratory, used mostly for student's training on the use of, the computer itself and office software. Thus, students and teachers, including of course mathematics teachers, don't use these facilities in a regular basis for teaching. (Cabero et al., 1997) says that some of the reasons teachers don't use the computer in the classroom, is the lack of knowledge on its use for teaching as well as a negative attitude towards them. We consider that the teacher is, perhaps, one of the most significant factor for the learning experience of the students in a classroom.

As an effort to improve mathematics learning using information technologies, we have developed an electronic learning environment based on Interactive Instructors of Recreational Mathematics (IIRM) (López-Morteo and López-Mariscal, 2005), following in part the recommendations of the USA National Council of Teachers of Mathematics (NCTM, 2002) for the use of information technology for teaching mathematics. We have developed a test collection of IIRM corresponding to a couple of topics of the curricula of mathematics courses of secondary Mexican schools, as intent to incorporate it into regular learning activities in the classroom. The importance of the search of new alternatives that improve mathematics learning outcomes in our students is stressed by the results of national (Backhoff et al., 2006) and international evaluations (OCDE, 2001), where Mexican students show a very low performance for applying its mathematical knowledge to solve problems.

Although remarkable studies have been made about the impact on learning of electronic devices (Cedillo, 2001), we believe there is a lack of stud-

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ies about of the programs by which the teachers have to be trained for a successful adoption of new technology in the classroom. In this sense, is not clear to what extend teachers' attitudes towards the use of computers contributes to its adoption for teaching as an strategy to improving learning. Also, we are certain that we need to develop a program for teacher training on pedagogical models that use technology as a learning strategy. According with this approach, in this paper, we present the preliminary results of a study of the computational literacy of Mexican teachers of secondary schools as a critical factor for the adoption of information technology in the classroom. Although initially we include teachers of all the courses of secondary schools, our main interest focus our work on mathematics teachers in order to develop a case study using our electronic learning environment and the IIRM.

2 THE INTERACTIVE INSTRUCTORS OF RECREATIONAL MATHEMATICS

Since 1999, we have been creating computer-based instructional material to contribute to the process of learning mathematics. The main objective has been to enhance mathematical skills and to help develop mathematical thought among users. For this purpose, we have been developing educational software components, specializing in mathematical concepts presented through recreational mathematics, called Interactive Instructors of Recreational Mathematics (IIRM) (López-Morteo and López-Mariscal, 2005).

We build the IIRM from self-contained educational content, designed to provide a ludic problem-solving approach for learning mathematical concepts and promoting a positive attitude towards mathematics. Conceptually, an IIRM represents an educational unit, composed of several elements –digital and rationale– with an instructional purpose on a well-defined mathematical topic. The IIRM, therefore, can be virtual laboratories, animated demonstrations, and simulation tools that represent different metaphors of computer-aided instruction such as the computer as a tutor, a pupil, a simulation engine, and as a tool, as described by (Crook, 1994). The IIRM conceptual architecture (Figure 1), consists of several elements that maintain a relation with the central element, in order to add some of their features to the main mathematical topic. These elements are: pedagogical support, ludic context, interactivity support, the telematics support, and the metadata element. The rationale behind this model can be consulted in detail in (López-Morteo and López-Mariscal, 2005).

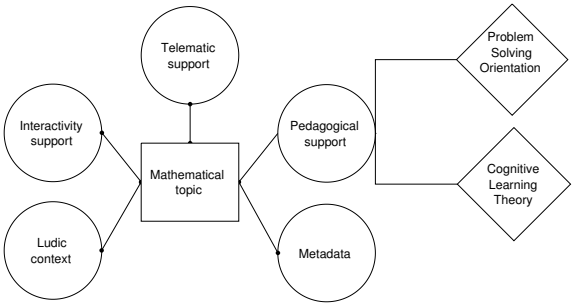

Figure 1: Conceptual model of the Interactive Instructor of Recreational Mathematics.

The learning environment has been tested in short motivationally oriented math courses for high school students. Based on different evaluations and a careful appraisal of the general attitude of the students in the course, the use of the electronic learning environment, as well as the approach imposed by the IIRM model shows a positive effect on the students attitudes towards mathematics. The use of this approach in formal education could improve students' mathematic skills, mainly by enforcing the motivational aspect of the learning process. The Learning Environment provides a close content-container relationship, resulting in interesting didactic materials, with which students using several services provided by the system in an non-intrusive manner.

Nevertheless, despite the IIRM has been proved its educational potential, we believe that it is necessary more information about the mechanisms by means of which teachers can incorporate it in the classroom. In the very first place, we located teacher's computational literacy as a elementary element for the adoption of these mechanisms, because of that we conducted a survey between teachers of secondary schools of the city of Ensenada, in Baja California, México. The survey was intended to classify teachers by its knowledge and skills about the use of the computer, office software, and Internet tools.

3 METHODOLOGY

The survey was called as *Self-Evaluation of Computational Knowledge for Secondary Teachers*, was applied to 20 of 40 secondary schools in Ensenada, and was answered by 193 teachers representing the 27.3% of the total population of teachers of these schools. The survey was based on the following programs, the Internet and Computing Core Certification

from Certiport, and the Microsoft Office Specialist. The items including questions about its perception of them knowledge on, computer hardware, operative system, common utility functions to applications (such as copy, paste, change fonts and layout, between others), word processor, presentation software, worksheet, Internet web applications, and e-mail. On an exclusive manner for mathematics teachers, we also include a special section designed as assertions following the classic Likert scale structure with a 4 ordinal scale, for their attitudes towards the use of information technology and recreational mathematics in education. The survey could be answered via the Internet, as a MS Word file, and in a printed form. As a complementary note, the last was almost the only method that teachers used to answer the survey.

4 RESULTS

From the 193 surveys answered, we found that 90.7% of the teachers have a home computer; from those the 91.4% already use it. The 64.8% has connection to the Internet, but only the 67.4% use it. Considering the gender, 61% were females and 39% males. The age range oscillates between 20 to 65 years old, where 54.7% have less than 40 years. The distribution of age ranges is presented in Figure 2.

Taking in account all the sections of the survey, excepting that restricted only to mathematics teachers, the results of the survey indicate that considering knowledge and skills about the use of the computer, 33.7% of the teachers are located in the without basic knowledge level, 31.1% are located in the basic level, 26.9% on the medium level, and only the 8.3% falls in the advanced level. The distribution of the level of knowledge and skills for the teachers, is presented in Figure 3.

Its remarkable that despite 82.9% of the teachers manifest that use the computer, almost the third part of them doesn't have the minimum knowledge to use it, according with the requirements specified in the two certification programs mentioned earlier. This possibly could be explained if we considered that most of the teachers only use the computer to perform very basic activities, such as write a plain document or simply browse the Internet, using a small number of applications. Another singular point is that the percent for the below minimum, basic and medium levels have similar values, showing a regular distribution among the group of teachers. Nevertheless, the total number of teachers with an advanced level corresponds to the teachers of computer-related courses.

Considering the age variable, the results show that of the 35.2% of the teachers with a medium and advanced levels, the 75% has less than 40 years. In the other hand, we found that in the group of teachers older than 40 years, are located the 69.2% of the total teachers than fall in the without minimum knowledge level.

About the technical knowledge related with the use of software, results indicate that the 25% of the teachers doesn't have a basic knowledge level on the use of the operative system, but 45% of the teachers use without problem the word processor. About the common utility functions to applications (such as copy, paste, select, change fonts, undo, redo, etc.), the 56% feels that manage it very well. However, the sections of the survey that present the highest proportion of teachers with the minimum knowledge level are presentation software and worksheets, with the 46% and 45% respectively; that is, almost the half of the group of teachers!

From the sample, the 36% doesn't have the minimum knowledge for Internet browsing, search content, print it and save it. In this section the rest of the levels have percent values of 25%, 27% and 12% for basic, medium and advanced levels respectively, where only the last two levels (39%) can also use discussion forums, download files, and manage a bookmark list. For the e-mail section, the percentages are very similar to the previous section. Here, the 40% of the teachers, including the 25% of medium level an the 15% of the advanced level, doesn't have problems reading, replying, resending, and managing their e-mails, besides they can attach files and use the address book. We want to stress that a relative small number of the teachers sampled, are the only ones capable to realize some of the typical activities associated to the use of software for education, especially in those models that use online applications and Internet based activities.

4.1 The Attitudes of Teachers of Mathematics Towards the Use of Information Technology

29 teachers of mathematics representing the 40% of the total answered this section. Remembering that this section was designed as a Likert scale with four scales, all the answers fall in the positive side of the ordinal scale, indicating that teachers consider that the use of recreational mathematics could be favorable to the learning process, could foster mathematics adoption, and could benefit mathematics learning if they use the adequate information technology.

The preferred delivery technology for content that help them to teach mathematics are, in descending or-

der, multimedia cd-rom (93%), web pages with multimedia content (79%), web pages with links for downloadable software (72%), discussion forums (10%) and chat rooms (8%). As a remarkable finding of these teachers, is that 31% of them have used information technology in their classes, where 66% has a medium knowledge level. According with (Heuvelen, 2001), teachers with experience in the use of the computer and technology innovations have proneness to adopt technology in their regular teaching activities.

Considering that the average knowledge in the use of information technology of the teachers sampled falls in the basic level, it could be possible that this lack of knowledge and skills limits the adoption of teaching models that use interactive computer-based content and electronic learning environments.

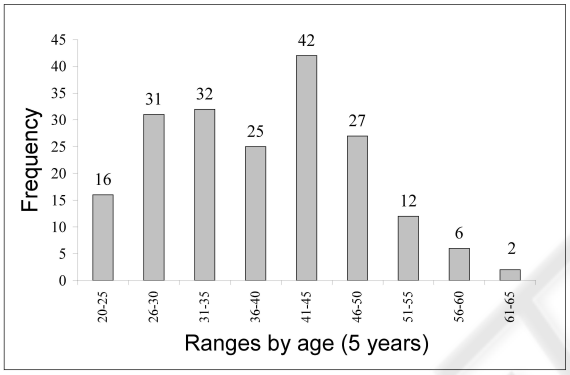

Figure 2: Distribution of ages.

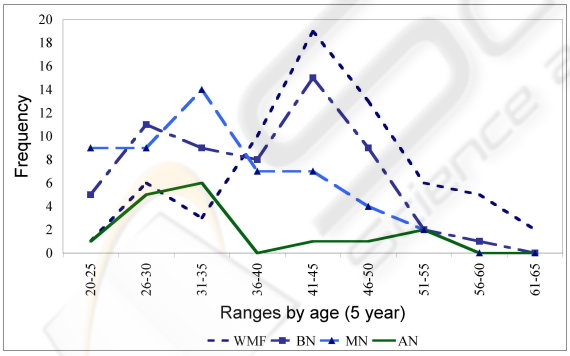

Figure 3: Level of knowledge and skills by age ranges. WMF=Without Minimum Knowledge, BN=Basic Knowledge, MN=Minimum Knowledge, AN=Advanced Knowledge.

4.2 Case of Study

In the first quarter of 2006, we conducted a field study in three secondary schools in the city of Ensenada. Two of them are public schools and one are a private school, we selected this three schools to perform a study following ethnographic techniques. We consider their computational infrastructure, how teachers used and the frequency students use it. In the study, participated three mathematics teachers of third year with groups of students between 14 to 15 years old (third grade of secondary school). Only the teacher of the private school reports that she has used information technology in her pedagogical practice.

We developed three IIRM for the curricular units according with the official Mexican program, following the suggestions and requirements of the teachers. The mathematical topics covered were factorization, parabola and Tales theorem. All of them can be consulted in Spanish at http://azul.cicese.mx/ galopez/marcos/semejanza/semejanza.html. The three IIRM follows the conceptual model presented before, providing interaction, a ludic approach and a problem-solving orientation.

Teachers were trained on the use of the electronic learning environment and the IIRM, with a training program developed exclusively for them in accordance with their knowledge and skills profiles derived from the preliminary survey. We emphasize the services that the learning environment provides, the pedagogical model embedded in the IIRM, how they can use it in the class, how the IIRM validate student's responses, and how they can solve simple technological problems with the learning environment. The training was performed using their schools computer laboratory. Each teacher had the freedom of selecting the way they can use the software with their students.

4.3 The IIRM in the Classrom

For this phase, we used qualitative observation techniques, a questionnaire and interviews with the teachers.

About the reliability of the learning environment. The system performs very well along the study. The three teachers believe the stability of the platform as an important factor for its adoption during the teaching process. They considering its use as transparent for the user, and work in every case without any trouble. As a remarkable point, we want to say that the learning environment has been working since 2001 without interruptions.

About the use of the IIRM from teachers point of view. Due to the learning environment worked with no complications, teachers have agreed that navigation through the platform were easy and the interfaces were simple to use. During the interview, teachers said while students worked with the IIRM, they had a better degree of interaction and attended more students during the class in the computer labo-

ratory compared with a typical day in the classroom. However we saw that the degree of interaction with students depended on the personality of the teachers. Two of the teachers considered useful to navigate the IIRM structure from the beginning to the end in order to accomplish the educative objective for that day, nevertheless the remaining teacher used only the embedded software to explore deeper the mathematical topic and to reinforce the concepts. During the class, we observed that the learning model associated with the use of the learning environment and the IIRM fostered collaborative work among students. In two schools, due to the positive results with the students, teachers decided to repeat the experience with another two groups.

About the use of the IIRM from students point of view. Students used the computer in groups of two to three. Nevertheless, some of the students work alone following the linear structure of the IIRM. Along the study, we observed that the interactive embedded software completely captures student's attention.

From the observations performed during the classes, we found that a critical factor that determines a successful experience of the teachers with the use of information technology was the technical support provided during the first sessions with students. We believe that the training for teachers in the use of new technologies in the classroom, should not be restricted to a one-time workshop, but it should be extended to the early phases of the adoption of this new way of teaching mathematics. We strongly suggest that teachers really need tutoring during this process.

5 CONCLUSIONS

(Braak, 2001) reports that experienced teachers on the use of information technology tend to perform better in the adoption of the technology in their practice. However, this preliminary study shown teachers with a basic level of knowledge and skills on the use of information technology and with a positive attitude towards its use, can incorporate it for teaching if they have an adequate training. Nevertheless, we believe that is indispensable that teachers should been introduced to the new educational models that incorporate computer-based learning activities.

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REFERENCES

Backhoff, E., Andrade, E., Peon, M., Sánchez, A., and Buozas, A. (2006). El aprendizaje del español, las matemáticas y la expresión escrita en la educación básica en méxico: sexto de primaria y tercero de secundaria. Technical report, Instituto Nacional de Evaluación Educativa México.

Braak, J. (2001). Factors influencing the use of computer mediated communication by teachers in secondary schools. *Computers and Education*, 36(1):41–57.

Cabero, J., Duarte, A., and Barroso, J. (1997). La piedra angular para la incoporación de los medios audiovisuales, informáticos y nuevas tecnologías en los contextos educativos: la formación y el perfeccionamiento del profesorado. *EDUTEC: Revista Electrónica de Tecnología Educativa*, (8).

Cedillo, T. (2001). Toward an algebra acquisition support system: A study based on using graphic calculators in the classroom. *Mathematical Thinking and Learning*, 3(4):221–259.

Crook, C. (1994). *Computers and the Collaborative Experience of Learning*. Routhledge.

Gorriz, C. M. and Medina, C. (2000). Engaging girls with computers through software games. *Communications of the ACM*, 43(1):42–50.

Gros, B. (2002). Knowledge construction and technology. *Journal of Educational Multimedia and Hypermedia*, 11(4):323–343.

Heuvelen, A. V. (2001). The workplace, student minds, and physics learning systems. *Am. J. Phys.*, 69(11):1139–1146.

López-Morteo, G. and López-Mariscal, G. (2005). Computer support for learning mathematics: A learning environment based recreational learning objects. *Computers and Education*, in press.

NCTM (2002). *Principles and Standards for School Mathematics*. National Council of Teachers of Mathematics.

OCDE (2001). *El estudio PISA de la OCDE proporciona datos internacionalmente comparables en cuanto al desempeño estudiantil*. Organización para la Cooperación y el Desarrollo Económico.

Sanchéz, J. S. (1998). *Experimentación en compañia: El aprendizaje colaborativo en Ludomática. Documento de Divulgación 04-98*. Universidad de los Andes, Colombia.

Wishart, J. (2000). Students' and teachers' perceptions of motivation and learning through the use in schools of multimedia encyclopaedias on cd-rom. *Journal of Educational Multimedia and Hypermedia*, 9(4):331–345.