A prototype application for helping to teach how to read numbers

*Diamantino Freitas, Helder Ferreira, Vítor Carvalho, Dárida Fernandes *, Fernando Pedrosa**

Faculty of Engineering of the University of Porto
LPF-ESI / DEEC / FEUP / Portugal
dfreitas@fe.up.pt, hfilipe@fe.up.pt, vitor@fe.up.pt, darida@mail.telepac.pt,

*Polytechnic Institute of Porto
Calculus / IPP / Portugal
fpedrosa@sc.ipp.pt

Abstract

Nowadays we see several multimedia math applications [1,2] in support of teaching the basic operations, geometric analysis, algebra and other complex operations; however there's no math application for the children at starting school age that helps to teach how to read a number in Portuguese. The *Laboratory for Speech Processing, Electro acoustics, Signals and Instrumentation* (LPF-ESI) at the *Faculty of Engineering of the University of Porto* (FEUP), started a project using a text-to-speech (TTS) engine and a Visual Basic multimedia application in order to fulfil that gap.
A prototype has been produced, called "*A Quinta dos Números*" (AQN) (*The farm of numbers*), that intends to create a bridge between engineering, computer science and pedagogy, using psycho-pedagogic concepts inherent to the teaching of maths, artificial intelligence, speech/text processing and multimedia systems, as scientific basis [3]. Developed to help the teacher to consolidate the student's knowledge and to support a progressive evaluation of her/his performance, AQN offers a multimedia interaction with speech synthesis and text boxes. It allows a greater accessibility at the same time it will offer a wide choice of didactic games, with learning and evaluation aims.

1 The role of ICT in learning Mathematics

School is changing. Programs, methodologies and attitudes are being renewed. The Information and Communication Technologies (ICT) are said to be tools, which facilitate the development of cognitive skills and enhance the power of communication. Specifically, the computer is accepted as an excellent instrument of education. Papert believes that the computer will provide the learners with the "materials" they need to build their knowledge in a constructive perspective, enhancing their autonomy and enriching the context where such construction evolves [4][5][6][7][8]. The National Council of Teachers of Mathematics [9] also points out as a pedagogic purpose the need of the curriculum from the 1st to the 4th school year to allow the appropriate and progressive use of technologic materials, namely the computers. The thoughtful and creative use of technologies can improve both the quality of the curriculum and the quality of the learning. That organisation also mentions that simulations of mathematic ideas in the computer can be an important help for children to identify the fundamental issues of mathematics. In fact, this association as well as many researchers [4][6] among others strongly believe that a significant way of improving the students' involvement in learning Mathematics is to use the computer as a mean of encouraging them to do research, explore mathematic ideas and to make use of mathematic relations in different contexts.

Fernandes [10] also supports that the learning context of the first cycle of basic school is favourable to the use of the computer as a work instrument, therefore, through suitable software, it is possible to promote the acquisition and the consolidation of concepts, as well as the development of the skill to solve problems. The mathematic reform implemented in the United States was significantly influenced by technology, which changed the way of "doing" elementary mathematics. All shows that an approach of Mathematics based on the computer leads to a better understanding of mathematic ideas and releases time for the development of new concepts.

2 Application features and requirements

The main concept explored in AQN is the simultaneous integration of the three media: text, graphics/animation and sound/speech. This allows the student to try and practice the in-full reading of numbers, and to play in free activities while performing evaluation.
The reading of numbers develops in a bi-directional structure of numeric categories and their readings, associated with graphic representation, animation and speech synthesis, with a clear correlation between text and numeric representation. A wide range of number types is available, for instance, cardinal, ordinal, roman, scientific, dates, phone numbers, and many other types of numbers. For the moment only cardinal and ordinal types are implemented into activities/games.

2.1 Visual Design and Interfaces

AQN is designed with a maximum resolution of 640x480 pixels, using only 256 colours (Windows palette) and Windows default fonts, allowing a good portability between different systems and equipments.

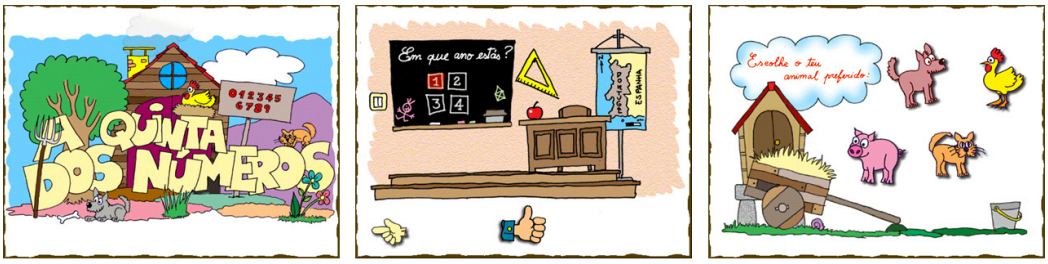

Figure 1: Screenshots from AQN. The first image shows the welcome screen, the second image illustrates the scenario where the children choose their school grade, and the third image shows where the children choose their animal companion that will guide them through the application.

In a design thought also in environmental terms, the student can travel through several farm-like scenarios, made of pictures with dynamic icons. These elements were created with the purpose of approaching children's universe (animals, fairy tales and objects from the classroom). Several animations and hidden elements were placed along the scenarios, providing a few surprises. The navigation is provided by menus and icons, the input devices are the keyboard and mouse. The practical and simple interface of AQN, based on pictographic animated icons and various sound events, allows this application to be used either as a didactic product integrated in school classes or as a self-learning product elsewhere. Figure 1 and 2 shows some scenarios from AQN.

2.2 Accessibility features

AQN is a disguised interface based on Visual Basic, with soft animations, not aggressive colours and intuitive sounds. All the buttons/icons have tool tip text. Messages to the user are of two types: static and dynamic. Static messages are reproduced by playing pre-recorded human voice (*wave* files). Dynamic messages are reproduced with the help of a Text-to-Speech (TTS) engine with a european portuguese grammar. All the numbers categories are marked up with LPF-ESI's mark-up language called *TPML* that identifies the type of number and directs the TTS's text converter in the conversion's decision.

Figure 2: Screenshots from AQN. The first image shows AQN's Talking Calculator, the second image illustrates an example game before start playing it, and the third image shows the resulting messages and icons after playing a game.

The combination of text, graphics and speech, enables a much stronger interaction and comprehensive teaching for the student, since she/he watches and listens to the number in question, relating the object and characters to the specific sounds. The capability of a TTS engine, also allows an extraordinary interactivity and comfort. When the student input's her or his name, the application will speak a greeting sentence including the entered name. That's found a warmer reception and is gratifying for the student.

2.3 Application requirements

AQN has the following requirements: 256 colours minimum, screen resolution of 640x480, Windows 95 to XP, nearly 25MB on hard disk, at least 32MB RAM, soundcard, speakers, keyboard and mouse. Visual Basic runtime files and Microsoft Speech API runtime files are provide at the AQN's installation.

3 Usability/Accessibility Evaluation and Results

A few preliminary tests were already made. AQN was tested with a group of students with ages between 5 and 7 years old enrolling the 1st and 2nd year of primary school. The tests were performed individually as well as in group. Some of the students had there the first contact with a computer. Each test consisted in a free experimentation phase followed by a questionnaire and a

task. The duration of each test was about 15 minutes. The application was evaluated in 3 different aspects: design and interface, text-to-speech evaluation and subjective opinion and evaluation.

3.1 Design and Interface

A few questions were made with the intention to evaluate visual perception and memory, navigation, animations, pictographic icons and spatial organization. The majority of the users collected the main visual information of the application (menus, titles and animations). A few problems were found with navigation between screens, mainly because the use of a few non intuitive icons. The selective learning options menu was found very confusing by the users. The "choosing favourite animal" screen was found very simple to understand and very intuitive to choose an animal and continue to the next screen. The main theme of a farm was enjoyable to the children. Some visual and audio elements were concealed in the scenarios. A few users found this disturbing at the first impression.

3.2 Text-to-Speech evaluation

The use of a TTS engine proved to be a valuable tool to improve the accessibility features and comprehension of the application, especially if the student has reading difficulties. However, we have found that good students with a good reading capability tend to almost ignore the TTS messages.
A few tests were made to evaluate the perception of the TTS voice. Most of the students were able to understand the text-to-speech engine; however the adaptation to the voice was fully visible only at the second or third experience during the application games. One of the features of the TTS is speaking the user's chosen name. This was found very rewarding to the children.

3.3 Subjective opinion and evaluation

In a scale of 1 to 4 (bad, normal, good, very good), AQN was evaluated in average by the children as a 3.
All users enjoyed very much the application's calculator and the animals present on the scenarios.
The game was found very intuitive and the TTS was found a helpful tool. However the TTS engine was found a little difficult to understand at the first time it is heard.

4 Conclusions and future trends of work

The accessibility of information was one of our prime aims, and the use of a TTS engine was a great tool to accomplish this requirement.
This application, if using a different interface but the same approach, could be used in other situations such as: Portuguese number's teaching for blind students (with the help of a Braille-output), for foreign persons or teaching older people (night-school). It could even be used as a kind of speech dictionary for numbers.
The immediate goal is to overcome some of the criticised aspects and test again the application with real users and also to evaluate its added value in the teaching activity. The extension to other types of numbers and operations is also envisaged. User customization also needs to be incorporated in the application. AQN will also provide a basic expert system that will try to understand the student's progress on the proposed exercises, detecting difficult levels and advising. Also, the teacher or pedagogic responsible, will be able to access the application's records for control, supervision and evaluation of the student's progress.

The text-to-speech engine and the basic expert system that guides and evaluates the student knowledge, combined with the inherent pedagogic aspects, make AQN an interesting application in its area, and a tool to consider.

5 Acknowledgments

The authors wish to thank all the teachers involved in testing and the following students: Nuno Santos, Clara Sousa, Filipa Torrão, José Loureiro and Alexandra Grandão, enrolling at the " Agrupamento de Escolas de Valongo: EB1/JI nº 4 ".

References and litterature

[1] Porto Editora Multimédia (2002) from http://www.portoeditora.pt.

[2] Teaching Ideas – Numeracy Numbers - http://www.teachingideas.co.uk/maths/contents2.htm.

[3] Jenny Preece. (1994). Human Computer Interaction. Addison-Wesley.

[4] Papert, Seymor. (1980). Teaching Children Thinking. The Computer in the School: Tutor, Tool, Tutee. (pp.161-176).

[5] Freitas, João. (1992). As Novas Tecnologias de Informação e Comunicação. Desenvolvimento dos Sistemas Educativos. Educação e Computadores ("The New Technologies of Information and Communication. Development of educational systems. Education and Computers."). GEP. Ministry of Education. II, (pp.27-84).

[6] Moreira, Maria L. (1989). A Folha de Cálculo na Educação Matemática ("A calculus sheet in mathematic education"). Department of Education. University of Lisbon. Portugal.

[7] Matos, João. (1991). Logo na Educação Matemática: um estudo sobre as concepções e atitudes dos alunos ("Logo in Mathematic Education: a study."). Department of Education. University of Lisbon. Portugal.

[8] Estrela, Maria T. (1992). Relação Pedagógica. Disciplina e Indisciplina na Aula ("Pedagogic Relation. Discipline and Indiscipline in the classroom"). Porto Editora.

[9] National Council of Teachers of Mathematics. (1992). Normas para o Currículo e a Avaliação em Matemática Escolar Quinto Ano ("Norms to evaluate mathematics in the 5th school year."). Institute for the Innovation in Education. Portugal.

[10] Fernandes, D. (1994). A utilização da folha de cálculo no 4º ano de escolaridade, estudo de uma turma ("The use of calculus sheet on the 4th year of primary school, study of a classroom"). Masters Degree. University of Minho. Portugal.

Ben Shneiderman. (1998). Designing the User Interface: Strategies for Effective Human-Computer Interaction. (3rd Ed). Addison-Wesley.

Microsoft Windows Guidelines for Accessible Software Design: Creating Applications That Are Usable by People with Disabilities - http://www.cs.bgsu.edu/maner/uiguides/msaccess.htm.

Program Nonium. Estratégias para a acção. As TIC na educação. ("Strategies for action. ICT in education"). Portuguese Ministry of Education.

Roe, P. (Editor). (2001). Bridging the Gap? COST, European Commission.

Text Processing Markup Language (TPML) was developed to mark-up text used in TTS. Contact the authors for more information.