AudioGene: Mobile Learning Genetics through Audio by Blind Learners

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Abstract. Science learning is a complex task for children at school age, especially for blind children. The purpose of this study was to develop and evaluate *AudioGene*, a game that uses mobile and audio-based technology to assist the interaction between blind and sighted children, and help them to learn biology and become more socially integrated. *AudioGene* was designed considering the communalities and specific particularities of the mental model of both blind and sighted users. The goals of this virtual environment were to integrate blind and sighted users, learn genetics concepts, and create ways of collaboration between them through the use of mobile devices. The software usability was evaluated and the results show that audio-based technology accompanied with ad-hoc methodology can play a role in the school integration of blind users. Relevant gains in this task as we expect from the initial results of this pilot study could reveal that mobile gaming can be a powerful tool for science learning of both blind and sighted students in school integrated learning settings.

1 Introduction

Science teaching and learning and particularly the concepts related to genetics are difficult to learn by the students due to the abstraction associated to the concepts involved and the impossibility of doing direct observation of phenomena and performing experiments to recreate similar environments.

The use of mobile devices eliminates the barriers imposed by the interaction in a reduced space (and not always available) such as a laboratory and allows a more fluid communication between the participants.

Diverse authors have analyzed the impact of games on problem solving. Some of them state that games can promote higher order learning skills, such as increased meaningful dialogues among learners [1]. Other studies also describe positive effects of games on social skills [2].

School integration and social inclusion are very important issues nowadays in

society and education. Several studies [3] to determine the role that technology can play in the school integration of users with disabilities into current classroom have been carried out.

Some studies have used interactive games for assisting blind people for learning and cognition purposes. AudioChile and AudioVida [4] are audio-based virtual environments oriented to enhance problem solving, navigation and orientation skills in users with visual disabilities.

Eriksson & Gärdenfors [5] propose web-based games for children with different visual impairments. They suggest two kinds of games: image-based games for children with partial sight and sound-based games for completely blind children.

Danesh et al. propose GeneyTM [6], a collaborative application for problem solving using genetics content through the use of PDAs oriented to sighted children and covering similar content of this study.

In the work exposed by de Freitas y Levene [7] a complete analysis of the development of mobile devices for education is presented. Emphasis is made on a way of using these devices for helping users with disabilities. As a result, they mention the benefits of new technologies in tasks such as locating places, help for mobility, and cognitive assistance for orientation in real environments.

In this study we propose and evaluate *AudioGene*, a mobile sound-based virtual environment for science learning and school integration of legally blind children with sighted children.

2 AudioGene

The metaphor of *AudioGene* was defined as a virtual gaming world including certain genetics concepts such as DNA, mutation, genotype, phenotype and gene. The contents were taken from the science school syllabus for 7^{th} to 10^{th} grade. The game was designed for mobile devices, in particular pocketPC devices, but allowing the possibility of be mapped by other mobile devices that have Windows as operating system.

The game contains different interaction zones for the characters controlled by students, such as lava, water, mountain and earth (see Figure 1). The game presents a story that consists in a tree of life that has certain characteristics and is dying so the goal is to replace the tree by another one with the same characteristics using a combination of seeds that will result in a similar tree.

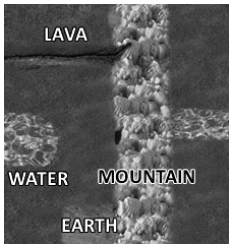

Fig. 1. Virtual world of *AudioGene* displaying different interaction zones for the characters controlled by students, such as lava, water, mountain and earth.

In order to achieve the goal of the game the user has to evolve the character chosen into superior entities. This allows the players to use the new acquired skills through the game in order to find the seeds that are spread throughout the virtual world. All new skills are gained during the acquisition of genetic knowledge through three ways: 1.The player travels through the world in a free way and interacts with the characters encountered; 2. The player solves a specific mission of the game, and 3. The player, in conjunction with his or her partners, solves the mission. The difference with the previous missions is that the other ones could be accomplished without the help of partners.

The fact of working with a pocketPC device restricts the design of the graphic interface due to its size. To accomplish this, we avoided the use of buttons and status information. Computer controlled characters also teach the users about contents concerning genetics through dialogs that are triggered as the user approaches them.

The audio interface is composed by two types of sounds. The first one is used for spatial orientation and consists in using sound clues. The second one is for learning contents about genetics using pre-recorded sentences.

These sounds may correspond to the area where the user is located. As an example, when the user is over the water, an associated sound to water is played.

In relation to the audio system, it is known that headsets only allow the use of 2 sound sources (A and B in Figure 2, left) which offer the option of 3 spatial combinations. The first two combinations correspond to only one of the sources being used (identified as left or right) and the other source match the use of both sources (which is intuitively identified as front) (see Figure 2, left). The proposed system consists in adding a new variable (C) to the sound system, which allows three new combinations and extend the spatial system to six combinations. When adding a rear sound to the user (C) we obtain a system like the one shown in Figure 2, right.

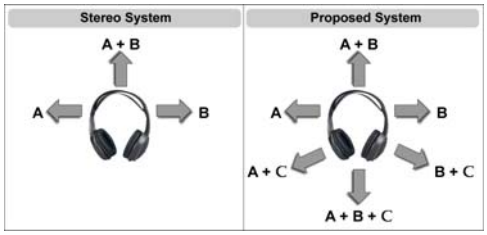

Fig. 2. Audio system proposed for *AudioGene* using an audio mask in comparison with the stereo system.

3 Research Methodology

The methodology to evaluate the *AudioGene* consisted of two stages. In the first stage, the usability was evaluated with end users. All blind children that participated in the study were legally blind; this implies totally blind and children with residual vision. In the second stage, the work dynamics in the classroom was analyzed,

considering aspects such as the motivation and the commitment of the students with this new way to learn (around a mobile game), the changes in the conditions of learning (interaction inside the classroom), and the results obtained in the cognitive development and specific learning. In addition, we studied the impact of using the game in the school integration of blind children with their sighted classmates.

3.1 Usability Evaluation

Three different groups that interacted with *AudioGene* were formed. Each group was consisted of 1 legally blind child and 3 sighted children forming a sample of 3 users with visual disabilities and 9 sighted users. The legally blind users were composed by 2 totally blind users and 1 user with residual vision with ages ranging from 8 to 12 years old. None of them had associated deficits. The sighted users had ages ranging from 8 to 14 years old. All blind users participated in the specific integration program. Two facilitators administered the tests to the children. The facilitators aside from orienting and helping children in the tasks also observed the behavior of the users when playing *AudioGene*.

Two usability instruments were used during testing: (1) End-User Questionnaire [8], and (2) Open questionnaire. The End User Usability test was administered to the participants of the study. This was applied at the end of the usability sessions. It is basically a software acceptance test and consists of 18 sentences with an answered scale of 10 points (minimum of 1 and maximum of 10). The Open Questionnaire consisted of 5 open questions that helped to identify the level of integration the game can achieve.

A facilitator provided a PocketPC to each user and gave them instructions for the task to be accomplished by playing the game as teamwork. Each team played during a session of 30 minutes with AudioGene solving collaborative tasks. In order to do this they had to coordinate themselves and define a strategy to attain the objective. Once the strategy was defined, students could play with *AudioGene*.

After the end of the experience end user questionnaires were administered. Each usability testing consisted of the following steps: introduction to the software, software interaction, anecdotic recording, application of evaluation instruments, session recording, session protocol reports, and software design and redesign.

3.1.1 Results

In general, the game was highly accepted in all categories for blind users (Satisfaction; 8.4 (out of 10); Control and Use: 9.2; Sound: 8.9) and sighted users (Satisfaction; 8.3; Control and Use: 8.8; Sound: 8.6; Image: 9.3). There were not critical differences between sighted users (see Figure 3) and blind users

From the “Game Satisfaction” category the assertions that obtained the highest scores in both blind and sighted users corresponded to “I would play again with the software” (9.3 and 9.7 respectively) and “The software is entertaining” (10 and 9.8 respectively). The asseveration “The software has different levels of difficulty” obtained the lowest score, 5.7 for blind users and 6.3 for sighted users, which reveals that this was the task with increasing level of difficulty while users solved tasks. In the “Game Control and Usage” category, the assertion that obtained the highest score

in both type of users was “The software is easy to use” (10 for blind users and 9.4 for sighted users). This result denotes the easiness of use achieved by the proposed interface of *AudioGene*.

The assertion “The sounds used in the software conveys me information” obtained the highest score from blind children, 9.7, and 7.3 for sighted users. This reveals the adequate selection of sound made for the game because they were useful for them to solve the tasks assigned.

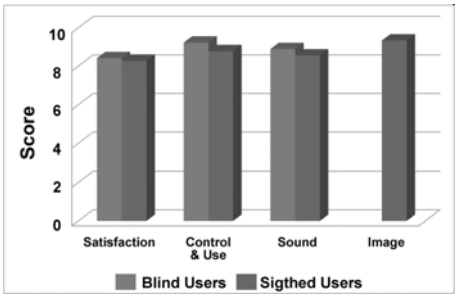

Fig. 3. Results of the usability evaluation of *AudioGene*

Learners commented that sounds were identifiable, high-quality and clear. They emphasized the fact that *AudioGene* let them work together, fully interact, and solve tasks collaboratively between blind and sighted children. They showed a high interest in the fact that characters were able to win skills and solve tasks in connection with these skills. A sighted student value the game because “*It made me work together with my blind partners*”.

In general, the answers obtained support the goal of the game for learning (the game is useful “*to interact with my friends and learn*”), and in some specific cases science learning (the game is useful “*to learn things about science*”).

The users were motivated in the fact that by using the new skills provided by *AudioGene* they can solve different group tasks. For the question, what did you like in the software? A sighted child answered: “*it is entertaining, interactive and we can learn more. I was very entertained because I had a mission with my partners*” Another child said: “*I liked to obtain powers (skills) because the questions were difficult and it was like a challenge*”. A blind child commented: “*I liked the lava because all of my partners entered to it and we all together could cross it*”

3.2 Learning and Social Integration Evaluation

The sample consisted of 5 legally blind children and 3 sighted children. These 8 students were distributed in two groups of 4 children each. Each of these groups was conformed by one blind user and 3 sighted users.

From the blind children, 2 were totally blind and 3 had residual vision. Four of the children assist to the “*La Maisonette*” school that currently implement an integration program and the other four children assist to the “*Escuela de Ciegos Santa Lucía*”, school specialized in blind students (see Figure 4). Both schools are

located in Santiago de Chile. Two facilitators participated in the evaluations; both of them were special education teachers specialized in vision disabilities.

In order to know what do children thought about the whole experience working with *AudioGene*, a short open questionnaire was used. This questionnaire consisted of questions such as, "How do you regularly play with your partners?", "What do you think about *AudioGene*?", "What do you think about this new way of learning?", and "Would you like to have more games like this one?"

Fig. 4. Children playing *AudioGene*. (A) "La Maissonette" school students (B) "Escuela de Ciegos Santa Lucía" students.

We wanted to know the novelty that a serious game like *AudioGene* can provide to children interaction and integration. The other questions focused on finding answers in the field of social integration and learning.

With the purpose of carrying out this research the following stages were followed: 1. Introduction to the game; 2. Collaborative gaming with *AudioGene* during a session of 30 minutes; and 3. Application of the open questionnaire. All evaluations were carried out in the schools.

3.2.1 Results

Some interesting answers from the children describe how they regularly play with other children. For example, when playing soccer, they put the ball inside plastic bags in order to hear sounds when the ball is moving. Thanks to these particular sounds children with visual disabilities are able to follow the ball movements and play soccer without problems. Most of them mentioned that they do not have common games to play between sighted and blind children.

All of them found that *AudioGene* was entertaining and motivating. They focused mainly in the possibility of accomplishing tasks in conjunction with their partners. Sighted children liked to be able to play with their blind partners. For blind children the fact of being able to work in conjunction with sighted children through the use of technology was a very good experience and they liked to be one of the participants of the teamwork.

For the question, did you like to play with your friend? All teams agreed that to play all together was a very good experience. All of them could participate and achieve the proposed objective as a team and also having individual tasks and responsibilities.

Children found that learning with a mobile game was more entertaining than reading books and also more motivating. Even a blind girl added "*I am going to propose it to the Madame…(her teacher)*".

They pointed that one of the advantages of *AudioGene* was that they can be all

together in teams interacting, playing and learning. An integrated blind girl states: "(I found it) *good, because all of us can be there and is entertaining to play with it. In the way that it teaches that all the people in the world are different; there is no person similar to another. Some can cross the lava, another one can cross the water but the ones that can cross the lava cannot cross the water…*" The idea behind this answer is that the metaphor used in the game teaches her that all people are different with different skills and virtues. One of the children supports the idea of creating and having more games for school integration and concludes "*… we cannot live in a world where all is made for the people that are sighted or in a world where the sighted are separated from the blind*"

About the question, would you play again *AudioGene*? All the children answered affirmatively to this question.

All of these answers inject motivation and ideas to continue working with this gaming tool and test its capabilities for learning biology concepts more fully in the near future.

4 Discussion

The purpose of this study was to develop and evaluate *AudioGene*, a game that uses mobile technology to promote interaction between blind and sighted children, social integration and in doing so, to learn science. We think that it is important to generate school spots where blind children feel motivated for learning and constructing knowledge. In this direction, new technologies can help immensely especially for communication and collaboration between sighted and blind children.

This new way of learning around a mobile game specially tailored to blind children, helps to improve the accessibility of all users to technology-based learning materials and thus improve their learning. Applications such as *AudioGene* open the possibility of creating more inclusive learning contexts where sighted users and users with visual disabilities can work together collaboratively and achieve common objectives.

The experience presented by Freitas y Levene [7] can be complemented with the results presented in this work. The use of mobile devices not only can assist the learning of legally blind users, but also by embedding applications such as *AudioGene*, can become powerful tools for school integration and social inclusion.

The positive effects of games on social skills mentioned by Pellegrini et al. [2] is corroborated in this work because the use of *AudioGene* allowed blind children to be socially integrated with their sighted partners, participating actively in social activities, and showing high interest and motivation for learning by using mobile gaming. From the comments made by the children we highlight the fact that the use of the game allowed legally blind children to work integrated with sighted classmates, feeling themselves as taking advantage of the school life. This result is very relevant to achieve a more complete learning beyond contents.

The fact that *AudioGene* is a mobile application allows the children to play inside and outside of their classrooms and learn more naturally in other nit fully explored learning contexts with the assistance of technology.

The remaining work in this study is to identify whether the biological concepts

embedded in the game are fully learned by the students, both by constructing new knowledge and complementing the knowledge learned in their regular classes. In addition, we should identify whether the virtual world provided by the game has to be extended to generate more degrees of difficulty in the learning tasks to be accomplished. We have to identify in a deeper way the degree of students' integration that can be achieved with *AudioGene*. Finally, testing the use of *AudioGene* in environments outside the classroom, like a museum, could be a challenging task in searching for innovative ways learning science.

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6 References

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