Science Learning by Blind Children through Audio-Based Interactive Software

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ABSTRACT

In this research we evaluated the impact of AudioLink, interactive audio-based multimedia software for children with visual disabilities, on science learning when used jointly with cognitive tasks. We present main results obtained when using this software during a six-month field study. Children were able to learn and practice scientific method processes and enjoy learning new topics by widening and enhancing their theoretical conceptualizations and acoustic perception. There were manifest physics learning gains; analytical cognitive skills were enhanced between pretest and posttest measures. In some participants these gains meant significant achievement. Children were also able to map, use and understand a game with a complex dynamic and interaction, and solved complicated science problems. We concluded that the use of AudioLink, combined with cognitive tasks, promotes scientific content learning and also enhances problem-solving skills during experimentation conveyed through the application of the scientific enquiry method.

Keywords: Blind children, cognitive evaluation, science learning, interactive software, virtual environments.

INTRODUCTION

Most children have difficulties in learning science, no matter their origin. The situation of children with visual impairments is poorer, since they have many difficulties accessing information, and science learning methods are designed mainly to take advantage of visual channels. A growing line of research on designing educational software for children with visual disabilities is using audio as the chief sensory channel to assist the construction of knowledge and meaning making (Kurniawan, et al., 2004; Sánchez & Flores, 2004). Although there are some software titles that support the development of mathematics learning and problem-solving skills (Shaftel et al. 2005) with significant gain for blind children (Eriksson & Gärdenfors, 2004; Mastropieri & Scruggs, 1992; Sánchez & Sáenz, 2006), no relevant work using audio-based science software to enhance science learning in blind children has been described in the literature.

The key issue in this research was the fact that teaching of science is tightly related to observation using the vision channel. Cognitive abilities for discriminating, classifying, sorting and recognizing objects, facts or phenomena contribute to prepare children to solve problems in real life. But traditional science teaching always uses vision as the chief channel to convey information, overlooking the remaining senses, which can actually produce more meaningful learning.

It should be said that at a motor level there are some setbacks in the development of basic skills in blind children (body knowledge, imitative behavior). However, at a cognitive level, they are absolutely normal, developing different perception channels, relaying more on the audio and tactile-kinestesic than sighted children.

The main purpose of this research was to evaluate the impact of AudioLink (Sánchez & Elías, 2006), an interactive audio-based multimedia software for children with visual disabilities, on science learning. The underlying questions of this study were: Can we develop scientific inquiry thinking (observation, stating a hypothesis, and doing experimentation) in blind children through audio-based multimedia software? Does this type of software assist the learning of science content? Can the use of interactive audio-based multimedia software enhance cognitive skills,
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both analytical (classify, relate, analyze and compare) and critical (evaluate, discern), as well as problem-solving skills?

We present the main results obtained when using AudioLink in a field study during a six-month period, combined with the utilization of concrete materials and cognitive tasks to learn and practice scientific method processes and science topics.

INTERACTIVE SOFTWARE

AudioLink is an action-platform role-playing game (RPG). When playing the game, the user controls a main character in a treasure hunt (see figure 1). The character navigates through a chain of connected stages that represents a fictitious world with streets, houses, and cities. He or she interacts with elements and characters that provide the quests to be accomplished and the clues needed to fulfill them. There are also side-quests that involve additional rewards. Hence, it is possible to incorporate different science concepts in a quest in such a way that each of these adventures considers the learning of one or more concepts. The game provides sequential, parallel, optional, and alternative stories, and the accomplishment of side-quests ends up with different game-endings.

![Figure 1. Main views of AudioLink](image)

METHODOLOGY

This study was divided in two stages. In the first stage, a usability evaluation was implemented to ensure that the product was usable for blind end-users. End-user and heuristic usability evaluations were applied; concluding that the product developed could be utilized by blind users independently. It was also verified that AudioLink is appealing, encouraging and challenging software that stimulates interaction. In this first stage a preliminary cognitive evaluation took place for the purpose of verifying whether the interaction of children with AudioLink implied a greater science understanding and application of the scientific method to analyze and solve problems. Two instruments were used: logging of user’s actions as recorded by the software and an open-question questionnaire. The results obtained indicated that users were able to perform most interactions embedded in the software and learners became highly motivated during interaction. AudioLink favors (in a game-based entertaining fashion) the development of skills related to the scientific method. Users were able to clearly identify the problems, understood that information was distributed in different zones, and explored the virtual world in order to retrieve it. Users mentioned that they enjoyed playing, faced different challenges and solved problems after planning and executing strategies. A complete review of AudioLink, usability evaluation results, and preliminary cognitive evaluation (scenario, sample) is discussed in Sánchez & Elías, 2006.

In the second stage of the study, which is the focus of this article, a complete and thorough cognitive evaluation was implemented. This evaluation consisted of a field study during a six-month period, combined with the utilization of concrete materials and cognitive tasks to learn
and practice scientific method processes and science topics. This evaluation was comprised of
three processes: software exploration, knowledge construction, and application. In the first
process, children interacted with AudioLink, learned the functionalities, and began to realize
the main purpose of the game. In the Knowledge construction process, children built pieces of
knowledge by interacting with AudioLink. They learned the embedded concepts (physics and
general science, see table 1) and also specific content of the game (characters, missions). Lastly,
they applied what was learned, working with the cognitive tasks as part of the AudioLink
scenarios.

<table>
<thead>
<tr>
<th>Physics</th>
<th>States of matter</th>
<th>Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardinal directions</td>
<td>Phases, states.</td>
<td>Direction, velocity, kinematics</td>
</tr>
<tr>
<td>States of matter</td>
<td>Phases, states.</td>
<td>Direction, velocity, kinematics</td>
</tr>
<tr>
<td>Weight</td>
<td>Weight, mass, volume.</td>
<td>Thermal and light energies.</td>
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**Table 1: Physics and Science concepts embedded in AudioLink.**

**COGNITIVE IMPACT**

**Purpose**
The main goal of this study was to develop scientific inquiry thinking skills (observation,
classification and experimentation abilities) in children with visual disabilities to analyze and
solve scientific problems through interaction with audio-based multimedia software. Furthermore, we evaluated whether AudioLink combined with the cognitive tasks applied
afterwards promotes learning physics and science concepts and the execution of necessary
actions to solve problems during experimentation.

**Scenario**
All software evaluations were carried out at the “Santa Lucía” school for the blind, located in
Santiago, Chile. Two special education teachers expert in vision disorders participated in the
evaluations.

**Sample**
The sample consisted of 7 blind students, ages 8 to 14 years old (10 years old in average). One
of them was totally blind, the others had residual vision. Three of them were female and 4 were
male. All of them were legally blind, according to Chilean laws that state that “an eye is blind
when its corrected visual accuracy is 1/10, or when the sight field is reduced to 20 degrees”.
This means that a legally blind person is able to see at one meter (3.2 feet) what a sighted one
can see at 10 meters (32 feet). They were familiar with computer interaction through a keyboard.
All of them also had attained expressive and comprehensive language skills and could utilize
reading and writing systems (Braille or Macro-type). The sample had an IQ score higher than 70.
We did not intend to have a larger sample because this was a case-study to provide in-depth data
and information about science learning through audio-based interactive software.

**Time Schedule**
Cognitive evaluations took place from April to October, 2006. Until July the evaluations were
scheduled twice a week and were 1.45 hrs per session. From August to October evaluations took
place once a week with a 3.5 hr. duration.

**Cognitive Tasks**
*Task 1: Little Researchers*
The purpose of this task was to develop scientific thinking skills through observation,
classification and experimentation, allowing learners to analyze and solve scientific problems. In
addition to these cognitive abilities, learning content was promoted. Cognitive requirements for this task were: spatial orientation notions, tempo relationships and sensorial integration.

Figure 2. Game board designed for the first cognitive task

The task was implemented with a board game specially designed for this activity (see figure 2). The board had 98 spaces with six groups of questions or situations, which compelled children to apply scientific thinking and problem-solving skills. Two teams were formed and took turns to roll a special dice (with Braille labels on each side). The dynamic of the game follows the model of Monopoly; thus according to the number obtained, the current player of the team in turn moves a playing piece to land in the corresponding space, and then the facilitator reads a card of the same color of the space. The six colors correspond to: problem-solving questions; chance cards (good and bad); content-related questions; AudioLink related questions; and special spaces that, for instance, can make a player lose his or her turn or get an extra one. Each team can earn points for every correct answer provided, more points are obtained if the current player answers without the support of their teammates. The game ends when one team reaches the central space, and the team that got more points is the winning team. Three sessions of this game were implemented in the study.

Task 2: Going for Scientific Thinking
The purpose of this task was to develop scientific thinking skills through observation, classification and experimentation allowing learners to analyze and solve scientific problems. Another goal was that learners solved problems through experimentation. The cognitive requirements for this task were the same as in Task 1. Two teams were formed pursuing the goal of rebuilding the relief puzzle of the world embedded in AudioLink by using concrete materials (figure 3-F). Nine pieces were provided to each team, and they were encouraged to finish the puzzle in the shortest time possible to win the game. To obtain the puzzle’s pieces, teams had to solve practical problems concerning the application of scientific knowledge and contents embedded in the software.
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Figure 3. Activities of the cognitive task: (A) Completing the puzzle, (B) Interacting with AudioLink, (C) Experimenting chemical reactions, using sodium bicarbonate inside a balloon, and a bottle with vinegar, (D) Creating a compass (using a cork over water and a magnetized needle), (E) Experimenting with states of matter using ice cubes, glass of water and facial steamer, and (F) the completed puzzle

Instruments
WISC-R
The Wechsler Intelligence Scale for Children-Revised (WISC-R) is a general test of intelligence, which Wechsler defined as "...the global capacity of the individual to act purposefully, to think rationally, and to deal effectively with his environment" (Wechsler, 1944). This scale consists of 13 subtests divided into two parts, verbal and performance. The test helps to determine the child’s ability to use practical judgments in social situations of everyday life. Each answer provided by the child has a score depending on whether it is appropriate and complete.

Procedure
To evaluate the cognitive contribution of AudioLink when used in combination with the cognitive tasks described above, we designed the following activities: First, a pretest evaluation was taken to measure the children’s abilities. For this evaluation, the WISC-R test was applied. Next, children interacted with AudioLink and solved cognitive tasks. The complete sequence of activities of this stage was: interaction with AudioLink, presentation of concrete materials for each task, team formation, setting ground rules, application and evaluation of the cognitive task. The order of the tasks was first Task 1 Little Researchers and then Task 2 Going for Scientific Thinking. Finally, a posttest evaluation was taken to measure the children’s abilities after the intervention. For this evaluation, the WISC-R test was applied. Likewise, to gather qualitative and quantitative data at the cognitive evaluation, questionnaires and photographic records were also utilized.

RESULTS
The small number of students did not permit extensive statistical analysis of the results. However, a case-study approach showed us that in the pretest, on average, students initially had a rather low performance, presenting poor skills in gathering and processing information about the local and more general social environment they deal with everyday. Many times they mentioned that “they would ask for adults to help” to solve a problem, evidencing that they have a strong dependence on others to make decisions. There was also a lack of ability to search, choose and utilize effective solutions to logic and everyday problems. The highest score obtained in the pretest was 22 (out of 34), which translates into an achievement level (AL) of
64.70%. The lowest score was 8 (23.52% AL) and the average score of this group was 13.14 (38.64% AL).

When contrasting pretest/posttest results, children clearly improved their performance (see figure 4). Many times children answered “I don’t know” in pretest questions or gave only one possible answer for each question. However, there was a clear gain in the number of posttest answers provided by children being even more appropriate and correct for the problems presented. They were also able to come up with more than one solution to each problem and verbalize it in a more elaborated way. This showed a new approach to problems by student, considering a more elaborated processing and selection of information. The highest score obtained was 24 (out of 34), which translates to an achievement level of 70.58%. The lowest score was 17 (50% AL) and the average score of this group was of 19.42 (57.11% AL). These results also show that the majority of students (with the exception of one of them who maintained the same pretest score) improved their performance, both individually and as a group. On average, there was an increment of 6.28 points in the standard score (18.47% AL). Also, the pretest standard deviation was 4.9, while in the posttest it was 3.7. This indicates that after using AudioLink and fulfilling the cognitive tasks children, as a group, became more even, especially those students with lower scores in the pretest performed significantly better in the posttest. It is important to notice that student number 3 (the totally blind participant) increased his achievement level by 20.6%, almost doubling his standard score and student number 5, with low vision, almost tripled his score.

**DISCUSSION**

This study shows that by utilizing AudioLink with the cognitive tasks, blind students faced a new way of gathering science-related information. Furthermore, they participated in several activities that motivated them to process, select, and use information purposefully. It is important to acknowledge the significant affect of these activities on most participants, some of them doubled and tripled their performance during posttest evaluation. Blind children learned to identify, select and apply different information to solve a given problem. There was a manifest increase in the number of answers/ideas provided as well as their correctness (score). Learners learned scientific facts and processes in a playful way, developing analytical skills such as classifying, relating, analyzing and comparing, and critical skills such as evaluating and discerning.

Cognitive tasks exercised attention, promoted the development of scientific thinking skills and favored the learners’ verbal abilities. The technology utilized facilitated the learning process and favored analysis and solving scientific problems by blind children. Children also showed a new way of interacting with AudioLink, searching for specific information to meet specific ends and hearing what each character told them, some of them even tended to stop the character’s dialogs after a few seconds. Although the activities required executing strategies independently, learners also interacted with each other to solve specific problems in teams.
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In the psychomotor area there was an improvement in the way learners explored and manipulated concrete materials. In the cognitive area they showed an appropriate degree of comprehension of the game structure and rules. Also, there was an improvement in how the students recognized information and how they applied knowledge using AudioLink and their short-term and long-term memory. In the affective area, students appeared encouraged and willing to participate in the process, being aware of their errors and asking for help when needed. Finally, regarding scientific thinking, students applied process skills such as observation, classification, verification and reflective thinking.

Each learner worked at his or her own pace, which allowed superficial and deep interaction with the software. Students were able to realize what part of the game is crucial to solve the current problem. The contents embedded in AudioLink combined with practical activities, provided learners the opportunity to challenge themselves by stating problems, hypothesis, and experimenting with problem-solving strategies, which ultimately led to accepting or rejecting their own hypothesis.

According to the results obtained, AudioLink, as a multimedia audio-based tool, combined with cognitive activities, can be utilized to support the development of some of the core scientific method processes. These include observation (auditory observation) to get scientific meaning of what they hear and thus increase their knowledge; experimentation by gathering several objects throughout the game learners have the opportunity of experiencing the consequences of using one or more items in different contexts and use several strategies to get a new item, enter a new zone or solve any problems during the game; and stating, hypothesis by picking items to be used sometime for some purpose and once learners have a new item, questioning themselves about what to do with it and how it can affect the plot of the story during the game.

Finally, the results of this study revealed that the use of AudioLink promotes scientific content learning (particularly physics) and enhances problem solving skills through experimentation by the use of the scientific method. These results also validate the use of this software as an attractive, challenging and effective way to learn science content and to develop scientific thinking skills, thus helping to close the gap in science learning opportunities between sighted and blind children.

REFERENCES


