Chilean higher education entrance examination for learners who are blind

J Sánchez¹, M Espinoza²

¹²Department of Computer Science, University of Chile, Blanco Encalada 2120, Santiago, CHILE

¹²Center for Advanced Research in Education (CARE), University of Chile Periodista José Carrasco Tapia 75, Santiago, CHILE

jsanchez@dcc.uchile.cl, maespino@dcc.uchile.cl

www.dcc.uchile.cl

ABSTRACT

In the context of the admissions process for Chilean state universities, there is a knowledge-measuring instrument called the University Selection Test (PSU, for its Spanish acronym). This instrument of evaluation is designed to measure the level of knowledge in various learning sub-sectors such as Language and Communication, Mathematics, History and Social Sciences, and finally Science. For each learning sub-sector, students use a paper facsimile with questions that each have 5 possible answer choices, which are recorded on a separate answer sheet. Based on a contextual analysis of the problems that people who are blind have with participating in the regular admissions process for Chilean universities, the purpose of this study was to design, implement and evaluate a digital pilot system that adapts the Chilean university entrance system, PSU, in the area of Language in Communication for people with disabilities based on audio and haptics. This pilot allowed for the inclusive, equitable and autonomous participation of people with visual disabilities in the university admissions processes. The results demonstrate the creation of a system called AudioPSU, which provides the necessary autonomy and respects the working time that each user needs to respond to the questions in the PSU. In addition, the system is shown to help users to map the structure of the PSU facsimile for Language and Communication. Finally, initial results show that AudioPSU allows for the integration of people with visual disabilities in the admissions process for Chilean universities.

1. INTRODUCTION

According to the WHO, there are approximately 314 million people in the world with visual impairments, of which 45 million are blind. The geographic distribution of this impairment is not uniformly distributed throughout the world, and approximately 85% of people with visual impairments live in developing countries (WHO, 2011).

In Chile, the results of the CASEN 2009 survey indicate that 7.6% of the population has at least some degree of disability, in which the most frequent disability (32.7%) corresponds to blindness or visual difficulties, even when using glasses (Ministry of Social Development, 2009).

Education in Chile is a sensitive issue for people with disabilities, for which reason their integration must take place as soon as possible. The ENDISIC 2004 survey showed that while 27.5% of the general population is currently studying, among the disabled population this shrinks to only 8.5% (Senadis, 2004).

In order to implement educational integration in Chile, the School Integration Project (PIE, for its Spanish acronym) emerged. PIE is a school system strategy with the objective of contributing to the continuous improvement of the quality of education provided in the school system, favoring presence in the classroom, participation and the learning of expected lessons for all students, and especially those with special educational needs, be they of a permanent or temporary nature (Mineduc, 2012).

On the other hand, regarding the admissions process to Chilean universities, managed by the Council of Rectors, there is a knowledge-measuring instrument called the University Selection Test (PSU, for its Spanish acronym). This instrument of evaluation is designed to measure the level of knowledge in various
learning sub-sectors such as Language and Communication, Mathematics, History and Social Science, and finally Science. The procedure for using this instrument functions traditionally with paper and pencil, in which students use a paper facsimile in order to read each of the questions (which include 5 possible answer choices), and once they decide on the correct answer they mark it on a separate answer sheet.

In this context, people who are blind do not have the necessary autonomy to take these tests. Currently in Chile only people with moderate visual impairment can take visual tests, using special aides and adequate lighting, almost like any other person who does not have any visual disability. For this reason, these individuals can be integrated into the knowledge-measuring process by taking the PSU, through a “special process” (isolated) for taking the tests, as they possess enough residual vision to be able to see the graphic elements contained in the test. During this special process they have the aide of two assistants; one in charge of recording what the person wants to answer, and another in charge of verifying that the first assistant adequately records what the visually impaired person has indicated. Furthermore, they are provided with additional time in order to respond to each test (Mineduc, 2011).

The previously presented needs and failures became the basis for public policy aimed at integrating visually impaired citizens into the PSU test-taking system, marking a landmark policy in Chile.

There is evidence of similar initiatives from other countries (China, 2002; Higher Education in India, 2011; Kaczmirek & Wolff, 2007; Katoh, 2002). Kaczmirek & Wolff (2007) presented guidelines for the design of self-administered surveys for visually impaired and people who are blind within a mixed mode approach (paper-based, Braille-based, Web-based). Katoh (2002) researched the use of tactile graphics in the entrance exams for Japanese universities, obtaining the result that learners who are blind are able to take tests with tactile graphics, but require more time to answer the questions than people with normal vision. Another possibility to balance this aspect is to eliminate the questions with graphics, as is done in the Swedish Scholastic Aptitude Test (Katoh, 2002). In India, special science exams in physics, chemistry, biology and mathematics were announced for 2012 and 2013. These tests will be adapted for students with visual impairments by excluding visual elements such as diagrams or graphics. In China in 2002, the possibility was opened for students to be integrated into the regular process for the national university entrance examination (China, 2002).

The purpose of this study was to design, implement and evaluate a digital pilot system that adapts the Chilean university entrance system, PSU, in the area of Language in Communication for people with disabilities based on audio and haptics.

2. AUDIOPSU SYSTEM

Based on the analysis performed by a multidisciplinary team of professionals involved in this work, in which special education teachers specializing in visual impairment participated together with computer engineers, the following baselines for the design of a system that contributes to improving the conditions in which people who are blind currently participate in the PSU were established:

- **Do not require special spaces to take the tests.** People with visual impairments must have the chance to take the knowledge evaluation tests in the same rooms as the rest of the people participating in the process.

- **Have an equivalent measuring instrument.** People with visual impairment must have the chance to utilize a knowledge-measuring instrument that is equivalent to the PSU that is currently used by sighted people. This can be achieved through an adapted computational system.

- **Does not require assistants.** People with visual impairments must have the chance to take the tests autonomously, just as the rest of the test-taking population. This can be made possible through the use of audio feedback for reading the questions, and the use of a haptic interface to answer the questions.

- **Having the advantages that sighted people have in order to navigate throughout the questions.** People with visual impairments must have the chance to make decisions on how to answer the questions, choosing the order in which they do so and thus have the freedom to optimize the time that has been assigned for them to finish the test.

In following these baselines for the design, a hardware and software solution was created called AudioPSU, reusing a longitudinal research work on audio for cognition in users who are blind leaded by the research group for more than twenty years (Sánchez, 2008). The application seeks to allow people with visual impairments to be able to participate in the Chilean University Selection Process in an improved and more inclusive way. This eliminates the need for an assisted PSU in which the user does not have the tools needed
to execute actions autonomously, and which was carried out in the context of a process lacking the normal conditions in which the university selection test is normally taken.

In order to design the software, the logic needed to structure the way in which learners review and respond to test questions, which is similar to the structuring of the sections included in the PSU, was integrated. This was made in order to provide more equal conditions for the measuring instrument used to determine entry into state universities. The solution integrates Text-to-Speech (TTS) to read the questions, and ad-hoc hardware to be used as an entry interface for people with visual impairments, in order to be able to navigate through and respond to the questions.

2.1 Software

The software consists of an adaptation to the Language and Communication PSU, which structurally possesses 3 different sections: I) Knowledge of basic concepts and general language and communications skills, II) Text production indicators, III) Reading comprehension.

There are 4 kinds of questions with varying specific forms included in the PSU Language and Communication test. Section I groups questions of the same kind. Section II has 2 sub-sections: A) Managing connectors and B) Writing plan, in which each sub-section groups a certain kind of question different from the other sections. Finally, section III is subdivided into various groups of questions, in which each group includes a common text made up of various paragraphs, which serves to resolve and answer reading comprehension questions for each group.

An Index of questions was implemented within the software, following the original test structure and thus allowing for a faster question review process. One of the navigational advantages that sighted people have on the paper test is the speed with which they can find the titles of the various sections of the test. To emulate this way of interacting and to reflect the desired level of navigation, it was decided to use navigation by sections for the entire test, in addition to a mode of navigation by questions in Section I, navigation by sub-sections and questions in Section II, and navigation by groups and questions in Section III. This allows the user to change quickly from one section to another, as well as between sub-sections in Section II and groups in Section III. It also included the option to go directly to a specific question on the test, granting the same degree of navigational freedom as sighted people.

Regarding the presentation of the questions, each question indicates its number and section or sub-section. At any time learners can ask for instructions, return to the index, go to the previous question, go to the next question, save the selected answer choice, or erase their previous answer choice.

For the questions in Section I, the learner is presented with the question and then the answer choices. In some cases, the question contains additional information, which is previously presented to the user, and he or she can access this information as often as needed.

For the questions in sub-section A from Section II, the user is presented with the sentence to complete, leaving a considerable pause in the audio where the connectors should go. In this way, the user can clearly identify where the connectors that must complete the sentence are to go. Finally, the user is presented with the answer choices, in which each of them presents the complete sentence with a series of different possible connectors.

For the questions from sub-section B from Section II, the user is presented with the title of the text to be completed, and then with the various sentences that could be used to complete the sentence preceded by an identifying number. The user can explore these sentences one by one as many times as necessary. Finally, the answer choices are presented, in which each one presents the order in which the sentences should go through their identifying number.

For the questions in each group from Section III, first the common text is presented, structured into paragraphs in such a way that the user can read each paragraph independently. Then the questions are presented along with the pre-answer choices for each question (if necessary). The pre-answer choices consist of numbered sentences in which the user must select which are true. The user can access each one independently. Finally, the answer choices are presented. In the case that there are pre-answer choices, each answer choice is made up of a list of numbers corresponding to the pre-answer choices.

For the questions in each group from Section III, first the common text is presented, structured into paragraphs in such a way that the user can read each paragraph independently. Then the questions are presented along with the pre-answer choices for each question (if necessary). The pre-answer choices consist of numbered sentences in which the user must select which are true. The user can access each one independently. Finally, the answer choices are presented. In the case that there are pre-answer choices, each answer choice is made up of a list of numbers corresponding to the pre-answer choices.

In some cases, words are highlighted in the questions, in that they are visually underlined. In order to highlight these words, quotations marks and capital letters are used, making the TTS announce the quotations and read these words with a higher degree of emphasis.
2.2 Hardware

The working environment for AudioPSU (see Fig. 1) is made up of the following hardware devices: (i) Netbook, preloaded with the software that controls the system and the data that makes up the PSU test facsimile for Language and Communication (see Fig. 1A); (ii) Numpad as the entry interface for navigation of the facsimile and for writing the test answers (see Fig. 1B); and (iii) Stereo headphones as the output interface, used by the system to provide the user with the questions and instructions through a synthesized voice (see Fig. 1C). A Braille symbol was incorporated into each key of the numpad, corresponding to an action within the system that users can easily identify (see Fig. 2).

![Figure 1. Work station for the AudioPSU user, (A) Netbook, (B) Braille Numpad, (C) Stereo Headphones, (D) User Who is Blind.]

The functions of the keys for executing the system were the following:

- “/” key. Allows for listening to the instructions corresponding to each section of the test.
- “*” key. Allows for going to the index of the section and asking where the user is located within the test.
- “-” key. Allows for going to the beginning of the index.
- “8” key. Allows for going from question to section, from sub-section to section, from group to section, from question to sub-section, and finally from question to group.
- “4” key. Allows for moving to the left between each section, sub-section, group and the questions.
- “5” key. Allows the user to choose entering into a question, section or sub-section.
- “6” key. Allows for moving to the right between each section, sub-section, group and the questions.
- “2” key. Allows for going from question to section, or from sub-section to question and from group to question.
- “+” key. Opens a window where the user can write a question number using the numeric keys and then press the “+” key again, and the system loads the corresponding question.
- “Back Space” key. Allows for erasing the number of the question in the selection window that is loaded after pressing the “+” key.
- “0” key. Allows for starting and pausing the text that the system is reproducing.
- “.” key. Allows for listening to the information regarding where the user is located within the test.

2.3 Interaction

The interaction with AudioPSU (see Fig. 3) starts with the user with visual impairment (see Fig. 3A) who, thanks to the numpad, can navigate (see Fig. 3B) between the various interfaces provided by the software (see Fig. 3C). The “Index” interface allows the user to select a particular question and see if it has been answered or not, and the structure of the “Question” interface allows the user to identify elements of the question such as the question phrase, complementary texts and the answer choices (see Fig. 3C). Finally, the system provides information regarding navigation through the text in order to resolve the questions through TTS, which can be heard through stereo headphones (see Fig. 3D).
During the development of the accessibility solution for taking the PSU in Language and Communication (AudioPSU), various institutions that work on the education and rehabilitation of visually impaired people were contacted. These included the National Union of Institutions for the Blind of Chile, the Santa Lucia Educational Center, the Hellen Keller School, and students within the University of Chile (Law School) and the Metropolitan University of Educational Sciences (Special Education School). These institutions were chosen in order to work with users who could help us to improve the design of the prototype.

This allowed for the selection of an adequate synthesized voice (tone and speed) for the reproduction of the texts. It was also possible to test the proposed navigation with the numpad and to identify if the distribution of the content facilitated total or partial comprehension of the test.

In this way, it was possible to generate changes in the software design beforehand, adjusting it to the needs of users with visually impairments, attending mainly to the suggestions that were provided collectively with the aim of implementing effective solutions from a variety of potential users of the system.
3.1 Sample

The sample was made up of a total of 7 people with visual impairment. Of these people, 3 were women and 4 were men, with ages between 17 and 23 years old. Of the total, 3 were from the Metropolitan Region, 3 from the Valparaiso Region, and 1 from the Bio-Bio Region. The sample was selected and managed through the National Disability Service, SENADIS.

<table>
<thead>
<tr>
<th>#</th>
<th>Gender</th>
<th>Age</th>
<th>Vision Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>20</td>
<td>Total Blindness</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>20</td>
<td>Total Blindness</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>17</td>
<td>Low Vision</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>18</td>
<td>Low Vision</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>19</td>
<td>Total Blindness</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>18</td>
<td>Total Blindness</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>23</td>
<td>Total Blindness</td>
</tr>
</tbody>
</table>

3.2 Instruments

A user satisfaction evaluation questionnaire regarding the use of the software was utilized for the end user evaluation, which consisted of an adaptation of the end user questionnaire “Software Usability Evaluation” designed by Sánchez (2003). This questionnaire is divided into two sections: In the first section, the users are asked to evaluate 12 sentences related to the use of the software, on a scale of 1 to 10, in which 1 corresponds to ‘very unsatisfactory’ and 10 corresponds to ‘very satisfactory’. The sentences were the following: (1) “I like the software”, (2) “The software is fun”, (3) “The software is challenging”, (4) “The software is motivating”, (5) “The software makes me active”, (6) “I felt I could control the situations in the software”, (7) “The software is interactive”, (8) “The software is easy to use”, (9) “The software adjusts to my rhythm”, (10) “I like the sounds in the software”, (11) “The sounds of the software are clearly identifiable” and (12) “The sounds of the software give me information”. In the second section, the users are presented with 6 open-ended questions, such as: “What did you like about the software?”, “What did you dislike about the software?”, “What would you add to the software?”, “What do you think is the use of the software?”, “Which other uses would you make of the software?”, and “Did you like to use the numpad? Why or why not?”. Also, an additional space was added to allow the users to express any opinions that they considered to be significant, and that they felt had been left out of the questionnaire.

Together with this questionnaire, a Non-Participant Observer questionnaire was also applied. Using this questionnaire, the facilitators recorded the following aspects for each user: start time and finish time of the experience, user’s location in the room, times of the significant events that occurred, questions asked by the users regarding the use of the system, perceptions of the user’s safety when using the system throughout the experience, use of the question navigation index, use of the “go to” functionality to navigate the questions, and interactions with the questions.

3.2 Procedure

The pilot project was carried out on December, 2010, together with the regular process for taking the PSU. This pilot project was carried out in 3 places at the same time (main Chilean regions): in the Republic of Mexico School in Santiago, Metropolitan Region, in the Quillota Terranova School in Quillota, Valparaiso Region, and in the Biobio F528 School, in Concepcion, Bio-Bio Region. The time for the implementation was 4 hours in each of these places.

The first stage of the procedure consisted in the installation of the workstation for the use of the AudioPSU system in each of the schools (see Fig. 4).

Afterwards the users entered into the room and were requested to take a seat at the workstation (see Fig. 5). Understanding the need to review the functionalities of the system regarding navigation with the numpad, adjusting the volume and testing that the application was working in optimal conditions, the facilitators proceeded to guide the users in exploring all of these points for about 20 minutes.

Afterwards, the composition and distribution of the contents of the PSU Language and Communication test within the AudioPSU software was described, explaining that the disposition of the sections was done in the same way as it is presented in the paper test. Then it was explained to the users that the time for taking the test was 2 hours, and the testing began.
As support for using the software, the user had a guidebook in Braille or Macro Type (according to the degree of the user’s vision) regarding the functioning of the AudioPSU application and the interaction keys of the numpad. Users were also provided with the test in Braille, giving them the opportunity to compare between these two modalities of accessing the information contained in the test.

In order to evaluate the users’ performance in using the AudioPSU applications, the facilitators in the room used the Non-Participant Observation Questionnaire, recording the relevant information regarding the experience. Faced with any questions or concerns regarding the functioning of the software, facilitators provided the users with any necessary assistance in order to respond to possible questions or solve certain situations, such as audio interference, problems with using the numpad, and the duration of the battery charge for the equipment.

Once the users had finished the tests, the facilitators proceeded to apply the Software Usability for Blind Children Questionnaire to each user.

4. RESULTS

The purpose of this study was to design, implement and evaluate a digital pilot system that adapts the Chilean university entrance system, PSU, in the area of Language in Communication for people with disabilities based on audio and haptics. The results obtained based on the application of the end user usability questionnaire showed that AudioPSU is usable and understandable for users with visual impairments. In accordance with the characteristics of the sentences included in the questionnaire, the results were grouped into 3 different dimensions: “Satisfaction” (questions 1, 2, 3 and 4), “Control and Use” (questions 5, 6, 7, 8 and 9), and “Sounds” (questions 10, 11 and 12), all evaluated on a scale of 1 to 10 points (see Fig. 6.).
The “Satisfaction” dimension obtained an average of 7.0 points. In this dimension, the sentences that obtained the highest scores were: “The software is motivating” and “I like the software”, with averages of 8.3 and 7.3 points respectively. Considering that the test is made up of 80 questions, this shows that the system was able to motivate the users to be able to take the test.

The “Control and Use” dimension obtained an average of 7.8 points. The most significant results within this dimension correspond to the sentences “I felt I could control the situations in the software” and “The software is easy to use”, which obtained average scores of 9.0 and 7.7 points respectively. These results show the ease with which the users could use AudioPSU, due to the fact that the user remains in control of his or her navigation through the application. The lowest score corresponded to the sentence “The software adjusts to my rhythm”, which obtained an average of 7 points, which is due mainly to the fact that the first version of the system does not allow users to configure characteristics such as the speed and timbre of the voice utilized in the application.

The “Sounds” dimension obtained an average of 6.6 points. The significant results in this dimension correspond to the sentence “The software sounds are clearly identifiable” and “The sounds of the software give me information”, which obtained averages of 7.3 and 7.4 points respectively. The lowest result corresponds to the sentence “I like the sounds in the software”, which obtained an average of 5.1 points, due mainly to the fact that the voice utilized in the TTS was not agreeable to all users.

Regarding the results corresponding to the open questions section, when asked “What did you like about the software?”, the users responded that the software is easy to use, that it allows them to take the test more autonomously, and that it presents users with a new opportunity for accessing the test. Participants also highlighted that the structure of the test in the AudioPSU software was the same as in the normal Language and Communication PSU test, as many had previously had the possibility to interact with the test, supported by sighted people in the case of the paper facsimiles and supported by a computer in the case of digital facsimiles of the PSU. When asked “What did you dislike about the software?”, users considered that an important issue is the voice used in the software, as in some cases this was not very fluid and they did not have control over the speed of the voice. As a result, when the user did not understand some word in a text, he or she had to listen to the text all over again, which took too much extra time in many cases.

When the users were asked, “What would you add to the software?”, the majority requested adding the option of controlling the speed of the voice, and making it more clear and fluid. When asked, “What do you think is the use of the software?” and “Which other uses would you make of the software?”, in general the users believed that the application could be used for any kind of test, such as in schools and universities, in order to facilitate study and evaluation processes. Finally, all of the users agreed that they liked using the numeric keyboard, as it is easier to use than the normal keyboard.

From the observations made during the test-taking process, it was noted that the users identified the keys on the numpad without any trouble; however, familiarization with the various functionalities of the software
is not automatic, and required a short tutorial period until the users were able to understand how to interact with and navigate the software. To overcome this problem, the fact that users could consult the Braille system user guide at any time was a big help, as they had the chance to resolve any problems by using their own strategies and means, without having to depend on the help of another person.

In general, the advanced functions of the software were not used, as navigation through the questions was performed sequentially. When the users wanted to return to a certain question, they achieved this through the “next” and “previous” buttons within the format of each question. Users were not observed to use any advanced functions such as to go to a specific question through the “+” key, or to return to the index through the “*” key.

Regarding the questions on the writing plan, it is very difficult for users to retain the correct order that the sentences should be in, to then seek out the answer choice that corresponds to the correct order.

5. CONCLUSIONS

The objective of this pilot study was fulfilled successfully. A digital pilot system that adapted the PSU in the area of Language and Communication was designed, implemented and evaluated, allowing people with visual impairments to participate inclusively, equitably and autonomously in the process for university selection.

Without a doubt, one of the advantages that AudioPSU presents compared to the current system for assisted test taking of the PSU is the degree of autonomy that the software provides people with visual impairments for navigating through the test, allowing them to make decisions and apply their knowledge. In addition, the system respects the working time that each user requires to respond to the questions, adjusting to their reading and hearing abilities.

In order to understand the functioning of the system and the numpad, it is necessary to perform a brief training session with users. This is held before taking the test, through instructions provided by the facilitators and with the support of accessible material, which allows users to learn of the various components of the system and the numpad, along with their respective functions.

It was observed that the system helps users to be able to map the structure of the PSU Language and Communication test, which contributes to their generating a mental model. However, a prior training session to learn how to use the system favored higher degrees of preparation and autonomy among the users.

The majority of the users were very accustomed to the use of synthesized voices as assistants in their experience with computer use. For this reason, the system must have voices that facilitate the change in the context of reading situations, both for extensive texts and specific actions regarding some questions within the test. In taking these requirements into consideration, it will be necessary to incorporate the option of reviewing the texts word for word, as well as implementing an accessible block of notes into a new iteration of the software, so that users are able to record their own notes or perhaps take audio notes. These aspects are proposed as future work in order to provide the user with a more fluid and user-friendly experience.

The users that participated in the pilot project felt nervous at first, due to the fact that they would have to perform all of the actions themselves, without any assistance as in the assisted test-taking modality. However, all throughout the experience they quickly understood the functionality of the system, being able to work autonomously without any problem, adjusting to their own work rhythm, and making their own decisions.

Regarding social integration, AudioPSU allows for integrating these users into the test-taking sessions within the same rooms used for sighted students. The system provides only the direct users with information, and does not generate any disruptive noises or interrupt the work and concentration of other test takers. In addition, in maintaining the same format as the normal PSU, users felt that they were finally considered able to interact with the test in the same way as a sighted person would take the paper test.

Finally, AudioPSU is positioned not only as an application that provides opportunities and access to the Chilean university admissions process, but as a tool that does not require a segregated social environment in order to function as well. Neither does it need any specific conditions that impede users from being included within the regular PSU test-taking process, offering an alternative option for special admissions processes designed for people with visual impairments.

Acknowledgements: This report was funded by the Chilean Ministry of Education with the cooperation and coordination of the National Disability Service (SENADIS), the Chilean National Fund of Science and Technology, Fondecyt #1120330 and Project CIE-05 Program Center Education PBCT-Conicyt.
6. REFERENCES


J Sánchez (2003), End-user and facilitator questionnaire for Software Usability. Usability evaluation test. University of Chile, Santiago, Chile.