Research on Accessibility of Question Modalities Used in Computer-Based Assessment (CBA) for Deaf Education

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Abstract. Virtual learning environments (VLEs) are increasingly being used for several purposes and audiences worldwide. VLEs are often used for communication with peers and with teachers, for sharing and collaborating on assignments and for assessments. Although the ultimate goal of distance learning is to make education available to anyone anywhere and at anytime, this goal cannot be accomplished unless VLEs are designed to be accessible to all potential students, including those with disabilities. In this paper, we investigated the accessibility of some question types (*e.g.* multiple choice, essay) used in Computer-based Assessment (CBA) in the Moodle platform, focusing on deaf students. Evaluation results indicate problems related to the use of videos, images, texts and customization for users. We also propose some design solutions for those problems.

Keywords: Computer- based assessment, deaf students, virtual learning environments.

1 Introduction

Assessment is recognized as a key element in learning, as it empowers, directs and motivates students and provides success criteria against which to measure their progress. The computer resources for the assessment process have the potential of becoming an essential educational advancement; they automate and facilitate the lengthy and tedious procedures involved in the design, delivery, scoring and analysis of assessment [Sim *et al.* 2004]. In many studies, teachers and students seemed to embrace this view and were positive towards Computer-Based Assessment (CBA). Some of the main advantages of this approach are the reduction of testing and marking time, the speed of results, administration of assessments, monitoring of students, the increased objectivity and security, less difficult or stressful [Thelwall 2000; Croft *et al.* 2001].

CBA offers opportunities for innovations in testing and assessing. Also, it can be used in many different fields [Chatzopoulou and Economides 2010]. Formative and summative assessments are the two major categories of CBA. Summative assessments help students to evaluate their effectiveness in learning. On the other hand, formative assessment helps students in reaching their targets through appropriate feedbacks

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[Turner and Gibbs 2010]. CBA used in the context of e-learning or in classroom education may help in assessing the learning. Currently, CBA is employed in both higher and secondary education [Kaklauskas et al. 2010]. CBA may be composed of different question types (or modalities), such as true/false, multiple choice, fill-in-the blank questions, assertion-reason multiple choice items, drag-and-drop items, problem solving simulations, and others. Also the level of complexity can vary according to the educational objectives as represented in the Bloom's Taxonomy that involves since questions that demand just remembering to analyzing, evaluating and creating solutions [Krathwohl 2002].

As CBA is increasingly being used in the educational practice, it is necessary to ensure that this type of assessment could be used for all, including persons with disabilities. Studies report accessibility problems in certain types of CBA questions, such as multiple choice and true/false that need to be solved. Luephattanasuk et al. (2011) investigated the accessibility of CBA questions in the context of blind students and interaction problems were reported. The authors also claim that more specific guidelines are needed to identify accessibility problems in the context of users with disabilities for interacting with CBA. In the context of deaf people whose main communication channel is the sign language, Bueno et al. (2007) claim that e-learning environments can be an appropriate way for supporting learning of deaf students. However such potential can only be explored if the courses are properly adapted since, among other differences, deaf students process images more easily and efficiently than words.

In this study we investigated the accessibility of question modalities used in CBA in the context of deaf students. We present the results of an accessibility evaluation conducted by experts in the field of Human-Computer Interaction (HCI) based on a set accessibility guidelines for interface designers of projects involving literacy of deaf people, proposed by Abreu et al. (2010). The evaluation involved some types of questions used in CBA by the e-learning management system Moodle as multiple choice, true/false, embedded answers (cloze), essay and matching. The guidelines used in this evaluation are based on W3C/WAI but are detailed in the context of deaf education. Evaluation results indicate problems related to the use of videos, images, texts and customization for end-users.

This work is organized as follows: Section 2 presents related works, Section 3 describes the evaluation methodology used in this work, Section 4 presents the results of the evaluation and Section 5 presents conclusions and future works.

2 Related Works

Virtual learning environments are used to refer the several kinds of on-line interactions that take place between students and teachers. VLEs have many features and capabilities such as forums, content management, real-time chat communication, electronic mail, quizzes with different types of questions, and a number of activity modules. There are several software systems available that provide VLE systems. Moodle is one of the most popular systems worldwide for e-learning system [Kumar *et al.* 2011].

Moodle is now used not only in universities, but also in high schools, primary schools, non-profit organizations, private companies, by independent teachers and even home-schooling parents [Martin *et al.* 2004; Koh 2006]. Moodle supports any types of questions used for CBA such as multiple choice, calculated, description, essay, matching, short answer, numerical, true/false embedded answers (cloze), and others [Sokolova 2007].

According to Burgstahler *et al.* (2004), VLEs offer opportunities for education and career enhancement for those who have access to a computer and the Internet. However, some potential students and instructors who have access to these technologies cannot fully participate because of the inaccessible design of courses. These individuals include those with visual and hearing impairments. Online courses can inadvertently impose barriers for students and instructors with disabilities. Web pages with complex navigation mechanisms can be difficult to use for people with mobility impairments. Content within graphic images may be meaningless to someone who is blind. Words spoken in an audio clip are potentially unavailable to someone who is deaf. Furthermore, according to Burgstahler *et al.* (2004), avoiding some access barriers can be simple. For example, text alternatives such as <alt> tags can be provided for graphics images for blind students and instructors be able of making sense of their the content. Likewise, captions on video and other multimedia products make content accessible to students who are deaf.

Potential students of an online course may have mobility, visual, hearing, speech, and other types of disabilities that could impact their participation. Today, most programs only deal with accessibility issues when a student with a disability enrolls in the course; they usually provide sticky solutions. Planning accessibility along with the courses is easier and therefore less expensive than quickly developing accommodation strategies, once a student with a disability enrolls in a course.

Seale (2006) conducted studies on accessibility in VLEs and concluded that the lack of knowledge about how to make e-learning accessible was evident, given the large number of external tools that had been developed to supposedly help teachers in this endeavor. Consequently, Seale argues that current VLEs are not appropriate to fit accessibility needs.

Power *et al.* (2010) evaluated the accessibility of the Moodle environment and found problems with text equivalents for non-text element, color contrasts between background and foreground colors; language appropriateness, and the size of large blocks of content that could be divided into manageable chunks. The evaluations presented in that study demonstrate that there are some relevant accessibility issues regarding the use of VLEs in the current practice. Those results demonstrate a need for training individuals responsible for developing, deploying and selecting VLEs to the adopted in institutions, regarding the accessibility lenses.

Hashim *et al.* (2013) argue that the use of e-learning environments for deaf students should help them in boosting their motivation level and at the same time, enhancing their performance in learning any subjects or courses available in schools or learning institutions.

In literature there are works related to the accessibility of VLEs in the context of deaf. Debevc *et al.* (2003) highlight there are also important guidelines for subtitles:

text in the subtitle should be equivalent to the spoken text; the subtitles should present sound information (*e.g.* phone ringing); subtitles should be presented inside the video frame in its lower part which is useful to deaf students. Khwaldeh *et al.* (2007) say that when designing and implementing an e-learning system for deaf students, one should consider offering all audio information in a visual way; subtitles for each video, picture, and text; a dictionary and glossary of terms; attractive and effective graphical user interface (GUI); an effective approach to navigate inside the learning material; several difficulty levels for assessments; and presenting e-learning material in a structured, understandable, and logical way. Drigas *et al.* (2005) proposed an e-learning environment for deaf students and emphasize the importance of presentation of bilingual information (text and sign language), high level of visualization, interactive and explorative learning, and the possibility of learning in peer groups via video conferencing.

Straetz *et al.* (2004) conducted studies on virtual learning environments for deaf students and concluded that for each block of text information should have an option to display the video information and this information presented immediately next to that information in text. That approach allows independent learning and gives the deaf learners the feeling that they are being taken seriously in their cultural and linguistic identity. The accessibility of e-learning was also improved when spoken text and other sound information are presented together inside the video. Besides its potential in improving the reading skills among deaf students, it will also enable them to learn independently [Debevc *et al.* 2012].

The literature review indicated that some studies already investigated the accessibility of deaf students in the context of VLEs. Some of them propose environments to be exclusively used by deaf students. In our work, we focus on the types of questions VLEs provide for being used by all students. For that purpose, the proposed design solutions discussed in this paper refer to adaptations in the Moodle environment, instead of proposing specialized VLEs, so that we expect the question types be able to support the learning process of students, including those who are deaf. We were not able to find literature approaching accessibility of question types used in CBA, in the context of deaf students.

3 Evaluation Methodology

The accessibility evaluation of the questions types used in CBA present in the Moodle platform is based on predictive assessment conducted by 2 experts and supported by a set of guidelines. The evaluation process consisted of: (1) Selection of a subset of guidelines that better fits the goals of this work; (2) Preparation of the evaluation activity; (3) Conducting the evaluation and data collection; (4) Analysis of the collected data; and (5) Reporting of results.

There are studies that provide general accessibility guidelines for web systems, *e.g.* W3C/WAI[1]. The W3C´s accessibility guidelines are useful for web content regardless

[1] W3C´s Web Accessibility Initiative. `http://www.w3.org/WAI/`.

context. However they do not provide detailed information on specific needs of deaf people or in specific domains such as education.

The work of Abreu *et al.* (2010) presents some guidelines geared specifically to deaf people accessibility and literacy. The set of recommendations were made based on a pair of investigative works. The first consisted of an analysis of the guidelines from W3C/WAI that took into consideration the culture and the needs of deaf people. Based on that analysis, Abreu *et al.* proposed a compilation of guidelines directly related to the accessibility of deaf users accompanied by a detailed explanation of their impact for this community. The second investigation was a qualitative research using the Method for Explicit Underlying Discourse (MEDS)[2] for identifying relevant issues to literacy of deaf children. In addition to the recommendations for the design of systems, the interviews allowed the identification of deaf children's literacy activities that teachers consider efficient for the learning process. This set can be useful to anyone interested in the process of literacy of deaf children, including the designers of systems for supporting the literacy.

In this work we selected some guidelines from Abreu *et al.* (2010) that best fit the context of use of question types of CBA for deaf students. For means of identification, the guidelines from the W3C/WAI begin with 'W', the guidelines generated by interviews with teachers of deaf students by 'I', and the guidelines related to activities related to the literacy process will be represented by 'A'. Next we present the selected set of guidelines for this work (free translation):

W1 – Use Transcription for Podcasts. Providing a transcript makes the audio information accessible for deaf or hearing impaired. Do not just make a literal transcription of the content. It must be considered how to present expressions and figures of language that are not easily understood by the deaf. For example, in the case of metaphors it must present the metaphor and a possible explanation associated to it. Moreover, if there is sound on the podcast along with the speeches, (*i.e.* thematic background music), they must be also identified.

W2 – Provide Alternative Texts Equivalent to Visual Content. Designers must provide text equivalents of non-textual content (*i.e.* images, video). Despite deaf people are able to see image or video, the transcript can be critical to facilitate their understanding of the meaning of visual content and/or its relationship with the text (if any).

W3 – Provide Several Ways for Document Reading. When a document with some important information is presented in the system, the content should be presented in text, video with information in sign language, or an avatar for translating the information for sign language, which is the first language of the deaf.

W4 – Adapt-the Interface Features for the Deaf. Designers can do whatever he/she want in the interface since he/she ensures that the contents, pictures and banners

[2] This is a qualitative research method through which the semi-structured interviews are guided in Humanities and Social Sciences. The main objective of MEDS in HCI, is making visible internal aspects of human nature important for the development of interactive systems as their preferences, difficulties, wishes, desires, etc. Its relevance for the field of HCI is the possibility to capture what is not tangible by other methods [Nicolaci-da-Costa *et al.* 2004].

are adapted to the reality of the deaf, which means that, when possible, the designer must use the sign language (video or avatar) to explain it.

W5 – Provide a Video Description of the Audio Information that is Relevant in a Multimedia Presentation. Supplement the text with graphic presentations or visual whenever they can facilitate the page/interface understanding. Designers must adapt all the information that is available in audio in the website or computer program, by providing it also in text. For any type of multimedia presentation (*e.g.* a movie or animation), equivalent alternatives should be synchronized (*e.g.* captions or text descriptions of audio clips, preferably in videos with the information in sign language). The deaf, due to its auditory limitation, need graphical or visual interfaces to facilitate understanding of presented information, since audio information and complex texts hinders the access of deaf people to the system.

W7 – Provide Information so that Users May Receive Documents According to their Preferences (e.*g.* language, content type). Designers must develop systems that provide information to the user according to their preferences. In the case of the deaf user, it should be able choose the language (verbal or sign language).

I3 – Provide Feedback to the Child about His/Her Activities, this Feedback Should Be in a Language that the Deaf Child Understands. The developed system, as any system, shall provide feedback to the child in relation to his/her activity and this feedback should be in a language the child understands (*e.g.* an image) or can even approach aspects related to the purpose of the system (*e.g.* associate images and words). This is important so that the child can use the system autonomously.

A1 – Consider Proposing Situations where it is Possible to Perform Activities in Groups or in Pairs. Deaf children learn a lot from the pair. Therefore, proposing exercises in pairs facilitates interaction and learning of deaf children since they have the opportunity of interacting with the system autonomously and also learn from his colleague.

The preparation of the assessment activity involved the configuration of the computing environment, the definition of the tasks and also the definition of procedure to be followed by the evaluators. The computing environment involved the virtual learning environment Moodle version 2.5. The tasks involved the questions repository in Moodle environment and the types of questions: multiple choice, essay, true/ false, embedded answers and matching. The procedure of the evaluation consisted of using the questions repository of the Moodle for instantiating each question type approached in this work. The evaluators took notes according the set of selected guidelines, by registering issues and possible design solution for them.

The data analysis is organized according to the 9 selected guidelines. We adopted a qualitative approach. For each problem found it was expected that the evaluators make suggestions for solutions whenever possible and necessary.

4 Results of Evaluation

This section initially provides information about the setup and conduction of the evaluation and follows witch presentation and the analysis of the collected data.

4.1 Scenario and Tasks of the Study

The evaluation was conducted by 2 evaluators that work in the area of Human-Computer Interaction. Both the evaluators are experts on accessibility in computer systems. One of them focuses on accessibility in the context of deaf people.

The questions repository of Moodle provides several types of questions that can be used to compose questionnaires. In this work we focus in 5 types of questions: multiple choice, true/false, essay, matching and embedded answers (cloze). In Moodle, for each type of question there are fields to fill in order to formulate the questions, the answers and the respective feedbacks.

Questions of the type multiple choice provides a field for formulate of the question (question text), fields to formulate possible alternatives of answer, and fields for general feedback and feedback for each alternative. For all these fields, Moodle provides an enhanced HTML editor called TinyMCE[3], henceforth called "HTML editor". Using this editor it is possible to insert text, images, videos, audios and others HTML elements. Table 1 summarizes the fields that provide the HTML editor for formulating questions.

Table 1. HTML editor availability by question type and field

Field	**Types of question**				
	Embedded Answer (Cloze)	**Essay**	**Matching**	**Multiple Choice**	**True/False**
Question	Yes	Yes	Yes	Yes	Yes
Answer	No	Yes	No	No	No
Feedback	Yes	Yes	Yes	Yes	Yes
Option Question	Yes	N/A	Yes	N/A	N/A
Option Answer	No	N/A	No	Yes	N/A

Essay questions provide the fields: question text, general feedback and the field for the answer. In all these fields, it is possible to use the HTML editor.

Matching questions have the field for the question text, general feedback and fields that must be attached to their respective correct answers. For the answers of this type question, it is necessary to select the correct answer using a "combo box" widget.

True/False question is composed of a field for the question text, general feedback and feedback for the possible answers. When answering this question type students must select an option in a pair of "radio button" widgets (*i.e.* selecting true or false).

Embedded answers (Cloze) questions are composed of a passage of text (in a Moodle's specific set of tags) that provide means for embedding several answers within it, including multiple choice and short answers. This question type has only one field with the HTML editor. That field is used for formulate questions, answers, and feedback. However, the answers can only be presented in text format *i.e.* it is not

[3] `http://www.tinymce.com/`

possible to insert video and images in the answer. The general feedback also can be formulated using the options of the HTML editor. Additionally, it is possible to provide feedback for the answers using HTML editor.

4.2 Collected Data

This section presents and analyses the collected data according to the selected guidelines, and are reported by indicating the question type and the situation in which the item was observed.

W1 – Use Transcription for Podcasts. In all types of questions analyzed in this work, there is no specific feature for transcription of audio and video. There is not any guidance for the creator of the question regarding how he/she could do it. Using the HTML editor it is possible to insert text transcriptions right below the media, however there is neither synchronism nor semantic relation (*e.g.* one specific HTML tag) between them.

In embedded answers questions in which the answers are composed only of textual information, an example of the use of the podcast or any other multimedia content to this type of question can be observed in Figure 1. In our proposed design solution, the selection of the answer could be implemented by an "radio button" widget followed by additional/redundant media, as for example and podcast or a video, so that teachers could provide different media for both questions and answers.

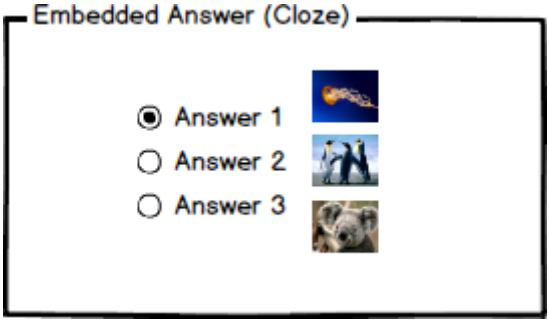

Fig. 1. Possible solution for multimedia use in the answers in question type embedded answers

W2 – Provide Alternative Texts Equivalent to Visual Content. In the types of questions that have fields with HTML editor, it is possible to insert the image description. This description is useful for screen readers or for using text-only mode. However, it is not possible to insert semantic markup for linking captions to pictures. A workaround could be inserting a text below the picture and use it as a caption. It is also possible to insert videos, but there is no option to insert synchronized text transcription for media. One alternative is to insert the video with embedded subtitles. For audio, a palliative solution could be inserting the text equivalent right below the audio. Another possible solution could be to provide an option to choose the default media for presenting questions. Such option could be placed at the user profile.

In the essay questions, the student can answer using the HTML editor, therefore it is possible to answer with media. However, the limitation is that it is not possible to record the answer lively. The user is supposed to use only prerecorded media. A possible solution could be to provide a media (audio e video) recorder for users so that they can answer essay questions using this resource for the answer.

The answers of matching questions are only text-based. A possible solution could be using a numbered index for each question and changing the answers to accept the HTML editor. Also it would be necessary to change the "combo box" widget in order to keep only the indexes from the questions, so that the constraint for answers with text only could be eliminated, since they would not need to be presented in the "combo box". Figure 2 shows an example of our proposed design solution for the question of type Matching.

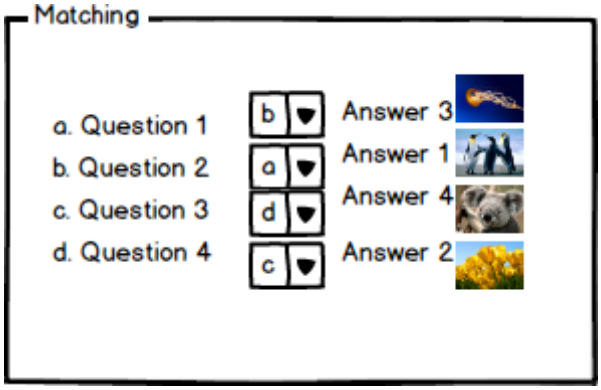

Fig. 2. Possible design solution for matching questions

Questions of the type true/false could be improved by inserting representative images for the texts of true or false in the selection of the appropriate answer. This resource would be redundant to the text already available.

W3 – Provide Several Ways for Document Reading. For all types of questions related in this work, there is no specific option in Moodle platform for inserting alternative media. In the HTML editor it is possible to insert several types of media (text, graphic, audio, video). However, there is no semantic link between one media and another. Also, there is not an avatar for translation of information for sign language, which is the first language of the deaf people

W4 – Adapt-the Interface Features for the Deaf. Moodle does not provide specific resources for the use of sign language or simplified text. Instructors could possibly insert some resource through the HTML editor, however there are no resources directed to this purpose.

W5 – Provide a Video Description of the Audio Information that is Relevant in a Multimedia Presentation. Supplement the text with graphic presentations or visual whenever they can facilitate the page/interface understanding. Again, it is possible to insert alternative media through the HTML editor, but it does not offer any specific resource to bind the media.

W7 – Provide Information so that Users may Receive Documents According to their Preferences (e.g. language, content type). Moodle not provide resources for this purpose. A possible solution could be inserting this option at the user profile so that user would be able to select the default media for presentation. However, regardless this option it is important to allow user to select media at any time.

I3 – Provide Feedback to the Child about his/her Activities, this Feedback should be in a Language that the Deaf Child Understands. All fields' feedbacks of all question types related in this work have the HTML editor; therefore the teacher can choose using text, image, or video to formulate the feedback. Assuming that the first language of the deaf is sign language [Chomsky 1998], it is possible to insert feedback information in sign language by inserting a prerecorded video.

A1 – Consider Proposing Situations where it is Possible to Perform Activities in Groups or in Pairs. Moodle does not provide specific resources for questions that could be answered collaboratively. Collaboration could be enhanced in Moodle by adding communication features (*e.g.* videoconferencing, chat) for specific students (a pair, a group) while answering the questions, so that groups of students could discuss the questions and collaboratively answer them, maybe using a collaborative text editor, an online video recording, a voting system based on majority or consensus, according to the question type.

5 Conclusion and Future Works

This work presented an accessibility evaluation of the question types supported by the Moodle platform in the context of deaf students. To do so, we selected some guidelines geared specifically for accessibility and literacy of deaf users.

The predictive evaluation was conducted by experts using the selected guidelines to perform selected tasks that involved the preparation of questions and answers for the set of questions types: multiple choices, essay, matching, embedded answers (cloze) and true/false; all of them supported by the Moodle platform.

The evaluation results indicate using the selected guidelines in this work has supported and allowed the evaluators to realize that some of these issues could receive less attention without this support. About the evaluated content (question types), we can conclude that there are some accessibility problems with those types of questions in the Moodle environment, most of them involving the use of images, texts, videos, audios, and user customization.

Further works include the involvement of users in the process of evaluation, in order to validate the results identified in this review and also validate the proposed design solutions. Lastly, we expect in a future be able to propose a consolidated set of guidelines for the development of accessible question types in the context of deaf students, for use in VLEs or other systems that could support question and answers features.

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