

Accessible QTI Presentation for Web-Based E-Learning

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ABSTRACT

Various guidelines for web accessibility have been issued to direct web developers to create web pages that deliver content to all. Although these guidelines cover most websites, there are some specific types of web pages that call for an extension of such guidelines. This research is dedicated to the improvement of accessibility of e-learning webs, particularly the examination portion. We chose IMS' Question and Test Interoperability specification (QTI) as a baseline framework, and extended it using Web Content Accessibility Guidelines (WCAG) to ensure that we could generate questions for exams that are accessible by all. Specifically, we proposed a method to interpret question structure from QTI specification using WCAG to help in presenting the interpreted questions in an accessible format. Finally, we developed a prototype interpreting tool to check whether the accessibility of the interpreted question is compatible with NVDA screen reader software. The performance of the tool at this stage is promising.

Categories and Subject Descriptors

H.1.2 [User/Machine Systems] *Human factors.*

K.3.1 [Computer Uses in Education] *Computer-assisted instruction (CAI).*

K.4.2 [Social Issues] *Assistive technologies for persons with disabilities.*

General Terms

Design, Human Factors

Keywords

E-learning, LMS, QTI, WCAG, Accessibility, Screen Reader, NVDA, Visually impaired person

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1. INTRODUCTION

E-learning is an important means of education for many, for it allows users to learn anywhere, anytime, and at their own pace. This is particularly useful for persons with disabilities, as it requires minimal traveling and investment, given a certain set of interaction with computers. However, without proper design, the offer of e-learning may not be accessible to all. Although Web Content Accessibility Guidelines (WCAG) governs most content presentation styles, there are still many activities that call for unique actions in the e-learning process, such as examinations.

One group of people who might face the most difficulties are the blind. Although the main alternatives for communication for the blind are Braille and voice, we chose to adopt voice because it is a less expensive option. Therefore, using voice as a means to communicate exam questions and choices of answers through a screen reader for the blind will be limited to certain types of questions, such as multiple choices or true/false. Other types of questions, such as matching, would certainly pose difficulties for the blind. Therefore, we have taken into account the Question and Test Interoperability specification (QTI) issued by IMS Global Learning Consortium, because it is a standard that has been widely adopted among developers in the e-learning community.

Past research related to e-learning and QTI can be grouped into three categories: (1) the development of tools to construct exam questions to comply with QTI; (2) the development of QTI presentation to be used with different technologies; and (3) the combination of (1) and (2) on different technology platforms. The work by Han et al. [2], which falls into the first category, offered a tool called dinsEditor that works on any popular browser and is able to generate questions in QTI format. Among the second category, Chang et al. [1] and Zualkernan et al. [8] proposed the presentation of QTI structure in digital TV and SWF formats, respectively. The works in the last category include those by Martínez-Ortiz et al. [5] and Zhang et al. [7], who offered a testing mechanism and the conversion of QTI structure to fit into Android phones, respectively. Thus far, no work has been devoted to the study of how to offer QTI structure that meets the limitations of the blind, specifically using a screen reader as a mode of communication.

Our work falls in the second category, where the aim is to propose a way to present questions with QTI specification that will work with the NonVisual Desktop Access (NVDA) screen reader. Starting with QTI, we evaluated possible obstacles for the blind,

given different types of questions. Then we identified types of questions that could be accessible by the blind utilizing NVDA screen reader software. Finally, we offered a method to interpret selected question structures along with WCAG guidelines, and developed a tool to support such a method.

2. BACKGROUND

2.1 Question and Test Interoperability (QTI)

QTI specification [4] is recommended by IMS Global Learning Consortium. Its aim is to reduce redundancy when creating questions for different learning management systems (LMS). QTI specification is used to describe data structure of questions and tests. Creating questions and tests that conform to QTI specification will help in transferring them into other LMS which support this specification. According to QTI specification, data structure may consist of question (item), section, assessment or object bank. This paper concerns data structure which contains only item. One structure can consist of one or many items, as shown in Figure 1.

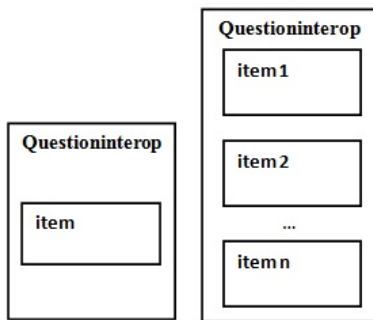


Figure 1. Data structure.

2.2 Web Content Accessibility Guidelines (WCAG)

WCAG [6] are guidelines for making web content more accessible. Following these guidelines will make content accessible to a wider range of people. A recent version of WCAG is 2.0. The principle of WCAG 2.0 consists of being perceivable, operable, understandable and robust.

This paper uses advantages from WCAG as a prototype in interpreting data structure of questions created to conform to QTI specification and presenting them in accessible format for blind users.

2.3 Screen Reader Program

A screen reader program is assistive technology helping the blind to work with a computer. It works with a text-to-speech synthesizer to read whatever is shown on the screen to users. Using a screen reader with a website which contains complex components, a screen reader will read from source code from top to bottom. The screen reader that we use in this paper is NVDA (NonVisual Desktop Access) because it is open-source and license-free software. NVDA is also easy to use and suitable for general users.

3. METHODOLOGY

3.1 Interpreting Data Structure of Questions

QTI specification states that one question or item may consist of two main parts. The first is the presentation part which can be described using a <presentation> tag; and the other is the assessment part which can be described using a <reprocessing> tag (see Figure 2). The part that we are interested in is the presentation part, which will be considered and interpreted to present the content in an accessible format.

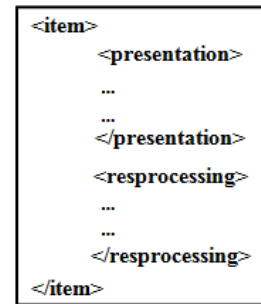


Figure 2. Data structure of a question.

To interpret QTI data structures, it is important that we know the types of questions that that data structures represent in order to present those types of questions in an accessible manner using WCAG guidelines. Therefore, we identified the types of questions by considering tags and attributes.

Shown in Table 1 are seven question types. These were selected out of a total of 20 types of questions that QTI specifies. The underlying criterion to select these seven is the limitation of users' interaction with a computer. In the case of the blind, we assume that it is not possible for them to use a mouse as an input mechanism.

Furthermore, we found that for these seven question types, we were able to present all questions using three presentation styles: (1) radio buttons, (2) checkbox, and (3) textbox. Radio buttons can serve standard True/False (Text) and standard multiple choices (Text and Images). Checkbox fulfills standard multiple response (Text). And textbox provides fill-in-blank (Integer, Decimal, and Text).

Our interpretation process is the process of mapping the question type to one of the three presentation styles. After the presentation style is known, we follow the WCAG guidelines to make certain that these three presentation styles will be accessible and readable by the NVDA screen reader.

Table 1. Question types.

Questions Types	Response Type Tags and Attributes	Render Type Tags and Attributes
Standard True/False (Text)	<response_lid rcardinality = "Single">	<render_choice > Number of <mattext>=2
Standard Multiple Choice (Text)	<response_lid rcardinality = "Single">	<render_choice> Number of <mattext> >=2

Standard Multiple Choice (Images)	<response_lid rcardinality = "Single">	<render_choice> <matimage>
Standard Multiple Response (text)	<response_lid rcardinality = "Multiple">	<render_choice> Number of <mattext> >=2
Standard Fill-in-Blank (Integer)	<response_num rcardinality = "Single">	<render_fib fibtype = Integer">
Standard Fill-in-Blank (Decimal)	<response_num rcardinality = "Single">	<render_fib fibtype = "Decimal">
Standard Fill-in-Blank (Text)	<response_str rcardinality = "Single">	<render_fib fibtype = "String">

3.2 Tool

We then developed a tool to allow users to download existing QTI questions in XML format, or to enter new questions using this tool. Once the questions are loaded, our tool will classify them into one of the seven question types and determine the corresponding presentation style. For example, if a multiple choice question with text choices is detected, the tool will automatically understand that it is a "Standard Multiple Choice (Text)," and automatically convert and generate the question with choices using radio buttons. Therefore, this tool will assist in most e-learning exam/test preparation processes and make them accessible and readable by the NVDA screen reader. As a result, the features of our tool include:

- Create seven basic question types
- Generate QTI-conformed questions from users' input inoperable with other QTI-ready platforms
- Interpret types of questions, identify presentation styles, and generate questions and answers that will be accessible and readable by the NVDA screen reader following the WCAG guidelines

Figure 3 shows an input screen where users may import or download existing questions.

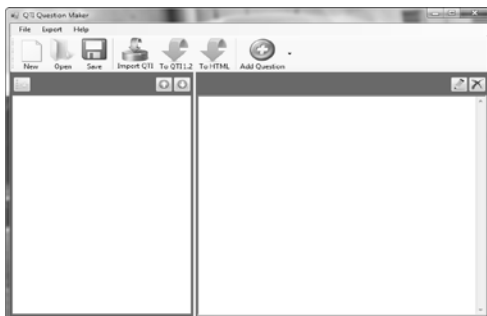


Figure 3. Prototype interpreting tools.

Figure 4 shows our interface, where the screen is divided into three portions: left, right and bottom. The left portion shows all questions and will allow users to select questions as desired. The right portion shows the details of the selected question, consisting of choices in the predefined presentation style. The bottom part shows the collection of control buttons that allow the user to navigate to different questions within the test.

After the user has completed the all questions for the test, the screen reader will read aloud the content from source code from top to bottom. We use JavaScript for all navigation buttons (Previous Undone, Previous, Next, Next Undone, Check Answered Question, Go to Question, Submit). JavaScript remembers the recent status of all questions and knows exactly which question is being viewed. Therefore, this function avoids confusion if the screen reader is being used by other programs at the same time. We also use JavaScript to screen the seven types of questions that are allowed in our tool.



Figure 4. Presentation screen.

4. EXPERIMENT

We set up an experiment to test the accessibility of our generated output. We imported 8 data structures of questions consisting of 7 data structures of questions in which one structure contains one question type, and 1 data structure of a question which contains many question types; then we used our tool to interpret the imported data structure of a question and exported it to an accessible format. After the questions were in an accessible format, we used AChecker, a web accessibility evaluation tool, to check the accessibility of interpreted questions against WCAG 2.0 (Level AA). AChecker categorizes problems into three types:

- Known problems: problems that have been identified with certainty as accessibility barriers
- Likely problems: problems that have been identified as probable barriers but require a human decision
- Potential problems: problems that AChecker cannot identify, and which require a human decision

The results are shown in Table 2. We then looked at each of the potential problems that call for a human decision and found that none of those warnings would harm or violate WCAG.

As a result, the outcome of the tool at this stage is promising. In addition, we are working on developing a mechanism to eliminate or minimize these potential problems.

Table 2. Experimental results.

Type of Question	Known Problems	Likely Problems	Potential Problems
Standard True/False (Text)	0	1	44
Standard Multiple Choice (Text)	0	1	56
Standard Multiple Choice (Images)	0	1	80
Standard Multiple Response (Text)	0	1	60
Standard Fill-in-Blank (Text)	0	1	40
Standard Fill-in-Blank (Decimal)	0	1	40
Standard Fill-in-Blank (Integer)	0	1	40
Mixed	0	7	112

5. CONCLUSION

This paper proposes a methodology and tool to interpret seven basic question types from QTI specification and to present questions in an accessible format, readable by a NVDA screen reader, so that blind users can use e-learning and make the tests accessible.

Although our tool shows promise, we are investigating further to develop a mechanism to minimize potential problems flagged by AChecker. Furthermore, we plan to test our strategy with real end users, the blind. Also, we may incorporate more question types to cover most of those defined by IMS' QTI.

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