Online Psychometric Design (OnPsyD) Tool

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Abstract. This paper discusses the architecture, and design of a research tool for online psychometrics. A few limitations of the current web-based tools available for psychometric research are discussed and the need for the OnPsyD Tool is laid. We provide a description of the database structure, and the architecture of the questionnaire presentation manager. The focus for OnPsyD Tool in this paper is the design of an extensible software architecture. Hence, new question types, extensions to existing question types, design style of questionnaires, and appearance of questions could be adapted easily. The paper concludes with a brief note on its limitations and extensions.

Keywords: online psychometrics, extensible database, design parameters for online questionnaires.

1 Introduction

The growing popularity of psychometric testing has penetrated every walk of life. In contemporary society, where technology is rapidly spreading, the traditional method of testing through pen(cil) and paper is being converted to online test administration. There is a plethora of research available on the advantages of online administration of questionnaires. In this research, a distinction is to be made between psychometric questionnaires and factual questionnaires or surveys. The former are, for example, used to measure customers' perceived quality of (online or offline) services and to measure users' interaction experience with a website in terms of flow experience [12]. Compared to the popularity of web-based surveys, there is very little research available to aid the design of online psychometric questionnaires and to ensure sound measurement. Because psychometric questionnaires do not measure factual information, it is more likely that the responses given are influenced by external factors, such as the presentation design of the particular questionnaire that is being administered. For example, research has shown a significant impact of presentation format on response quality [14] [15] and substantial differences in information-processing style between western and eastern cultures [10], with potential implications for using psychometrics in any domain. Empirical research is therefore needed to develop knowledge in particular for the presentation of online psychometrics. Therefore, a technical system is required to support research on design parameters in online psychometrics.

With a plethora of survey tools available currently, an obvious question might be why there is a need for another one. In contrast to the available survey software tools, OnPsyD Tool is developed solely for research and hence gives researchers access to source code to add more functionalities and contribute to a repository of psychometric data collected with the tool. This paper describes the architecture details of the software.

Human-computer interaction (HCI) is the study of interaction between people (users) and computers. After the inception of psychometrics in the early 1900s, it was during the late 1970s, that psychometric questionnaires started to be used to measure the quality of human-computer interaction [5]. For example, research by Ahuja and Webster [1] led to the identification of two distinct scales to measure disorientation and perceived ease of use. Factor structure and psychometric properties such as reliability, validity and sensitivity [6] were confirmed through empirical research on these scales. In another study conducted by Davis and Wiedenbeck [2], a new scale to measure flow, defined as a psychological state of a person to feel cognitively efficient or motivated and happy [9] during Web use, was developed. Research by van Schaik and Ling [12] [13] [14] established the psychometric properties of these scales in empirical studies measuring the quality of human-computer interaction. The recommendation of this research focused on investigating a comprehensive set of design parameters and experimental manipulations of web site parameters to demonstrate sensitivity of measures and quality of human-computer interaction [14]. Accordingly, the OnPsyD Tool will provide a framework for this research.

2 Problem Statement

Various research studies demonstrate how usability science, along with other research in HCI, can benefit from the application of psychometrics in our daily life such as assessment, information search, and diagnostics. However, the way psychometric instruments are presented on-line and respondents' interaction with on-line instruments can influence measurement [12] [14]. Because psychometrics models human psychological characteristics, it is important for instruments administered on-line to be sound and standardize in terms of measurement. Very little research exists in online psychometrics that addresses psychometric measurement in human-computer interaction through web applications or mobile applications. Large-scale empirical research is required to develop a comprehensive understanding of online psychometrics. This research addresses the following problems through the development of the OnPsyD Tool. First, existing software tools do not offer good support for experimenting with visual design in questionnaires. Second, there is a lack of separation between content, style and design of online questionnaires is prevalent in existing software tools.

3 Architecture

3.1 General Software Description

The focus of the development of the OnPsyD Tool is on the design of an extensible software architecture. OnPsyD Tool will be available as a research tool for online psychometrics. The visualization of questionnaire items remain separated from the questionnaire content. This separation allows researchers to efficiently create experiments to test the effect of presentation style across a range on content. One of the main tasks is the storage of questionnaires. As questionnaires contain items from a shared list, one questionnaire item could be a part of one or more questionnaires. The same questionnaire exists with different presentation styles. The response for each questionnaire item is stored in a database according to different design parameters. The implementation of the different modules of the OnPsyD Tool is based on the MVC (Model View Controller) architecture. The model represents data and the rules that govern access to and updates of this data. In enterprise software, a model often serves as a software approximation of a real-world process. The view renders the contents of a model. It specifies exactly how the model data should be presented. If the model data changes, the view must update its presentation as needed. The controller translates the user's interactions with the view into actions that the model will perform [3].

3.2 Questionnaire Items

A questionnaire item contains an item *stem* and a *response* part. The attribute description is the item *stem* that is composed of full sentences, phrases or single words. The *response* part is the measure that describes the degree of the attribute description and varies according to different response formats, such as rating scales (e.g. Likert scales) or binary anchored phrases (e.g., yes-no, agree-disagree). The response part is involved in item presentation and response collection. There are different question types such as

- bipolar scales, in particular semantic differential;
- graded/discrete response format such as a Likert scale;
- visual analogue scale or continuous scale;
- pictogram question, where pictures represent textual alternatives;
- matrix question, where multiple questions have the same alternatives as their response.

Due to the similarity of the structure of different questionnaire item types, object-oriented concept of inheritance is used to model their similarities and their differences in an integrated fashion. The UML representation for the class Question is provided in Figure 1. Thus, variations in the structure of existing items and addition of new questionnaire items are incorporated without much change to the software design. The UML represents the structure of the questionnaire item that could be represented with different design patterns. The architecture of separating content and style allows an

item to adapt to different presentation styles. Response formats each have their own advantages and disadvantages. For example, research has identified advantages of discrete and visual analogue formats for Likert and semantic differentials [12] [4]. Allowing the a questionnaire item to adapt to different presentation styles through the OnPsyD Tool supports further research on response formats in a systematic and efficient way.

Fig. 1. UML Diagram of class Question

3.3 Responses

The other focus of the software design is on the storage of responses. The user's response to each item is stored into the database as it is completed. The mapping of the user's response is very important. Every response recorded for an item will be associated with the item itself along with the type of response format, the presentation style and the questionnaire that was administered. The response will also record the response time. However, this will be achieved through client-side implementation, depending on the loading of the page and the response to the questionnaire items subsequently.

3.4 Design Parameters

For the initial implementation stages of OnPsyD Tool, only a limited set of design parameters is included in the architecture. However, a comprehensive set of design parameters will be implemented and made available for research purposes. Important parameters include response format, questionnaire layout, and interaction mechanism.

Response format. Different types of response format have already been mentioned in Section 3.2. These formats will be recorded in the database with unique identification number, to enable mapping between the questionnaire item, visual representation and the response.

Questionnaire layout. There are different ways of partitioning questionnaires for online presentation [11]. Implementation in the functionality module will include design of questionnaires according to each presentation layout. However, in the database, each layout will be recorded with a unique identification to enable mapping between layouts, items used and the different response formats for the items. Research reported by van Schaik and Ling [14] investigated the presentation of online psychometric questionnaire as whole form (all items in one page) and as single item presentation (one item per page). However, a large-scale empirical analysis is required to investigate various questionnaire layout presentations, and hence the implementation of the OnPsyD Tool will be of significant importance.

Interaction mechanism. Interaction mechanisms, such as direct and indirect, can be distinguished. For example, in direct interaction, users can immediately select from a set of visible options (e.g., radio buttons), whereas in indirect interaction users can choose from a set that will become visible when interacting with the control (e.g., drop-down list). Possible interaction mechanisms for different response formats will be stored in the database along with their unique reference number. This will enable mapping between questionnaire item, its response format, the interaction mechanism and finally the questionnaire layout. Empirical analysis on the data collected may exhibit effects that could be of importance for the quality of responses in online psychometrics.

3.5 Presentation Manager

A web-based presentation manager integrated with the database will administer the questionnaires. For example, the presentation manager will map and store the different presentation styles, items for the questionnaire and the design parameters such as response formats into the database of a questionnaire that has been designed. Further, the manager will administer the designed online psychometric questionnaire through the Web. The presentation manager will also facilitate collecting responses back into the database. Finally, the presentation manager will facilitate the export of responses and other related data for data analysis by statistical software (e.g. SPSS).

4 Implementation

The software for the OnPsyD Tool is divided into subprojects to ensure the capability to re-use components. In addition, the model-view-controller architecture significantly reduces time involved in developing the user interface. The main components are

- Users Module – the module to creating administrators and users
- Functionality Module – the module for the core functionalities like creating questionnaires according to various design parameters
- Web Module – the module to administer the questionnaire online
- Database – the module to store data: user details, questionnaire details, design parameters and responses

4.1 Users Module

The Users Module manages two different kinds of user, administrators with administrative privileges and other registered users who can participate in experiments, as part of online-psychometrics research. The login session for administrators to create and administer research experiments is web-based. Registered users will be invited via email and registered with unique user-id and password. The participation of the users in research experiments will also be web-based in either controlled (e.g. lab) or uncontrolled (e.g. home) environments. The users will be first required to agree to participate through an online consent form before the start of the experiment. Participants will be able to exit from an experiment any time.

4.2 Functionality Module

This module is the core of the OnPsyD Tool. Since the tool's focus is separation of questionnaire visualization from its content, the functionality module contains the necessary implementation. One of the main tasks is the storage of questionnaire. The mapping between questionnaire items, design parameters and questionnaire is coded and stored in the database. The functionality module also facilitates presentation of

questionnaires according to different layouts. Furthermore, the module supports the export of database data collected in psychometrics experiments to formats (e.g., csv) for analysis by statistical software (e.g. SPSS).

4.3 Web Module

The web module facilitates administration of questionnaires and collection of responses. Client side implementation will include collection of general data such as screen resolution, optional IP address, and operating system details.

4.4 Database

The initial design for the OnPsyD Tool is illustrated in Figure 2. This initial design comprises of tables such as user details, the questionnaire layout, questionnaire items, the questionnaire itself, and response format. Foreign key references between entities enable mapping of required data for empirical analysis.

4.5 Current Stage of Implementation

The implementation of the OnPsyD Tool is in the initial stages. Currently, the User Module and the database design have been partially implemented. Once completed, the tool will be deployed on a Web server and the source code will be published online for reference and use as a research tool.

5 Results

As noted above, the important effort here is to produce a flexible research tool with an extensible architecture. With very little research available currently, it is expected that OnPsyD Tool will help increase research in the study of design parameters for online psychometrics. Eventually, psychometrically sound instruments with design features that help bring out the best results in terms of measurement will contribute immensely to the field of HCI and the practical application of sound online psychometrics.

Contribution to HCI. The important aim of developing psychometric scales, is to help make “IT products better suited for human” [8]. Hence, design parameters that affect online rating scales are of prime importance in research. Furthermore, the tool will facilitate storage of data that can help in analyzing and determining utility as one of the factors for new or existing scales. Utility is the degree of usefulness for which a scale is developed [8]. Besides, the database modelling enables data collection from experiments conducted in different (social and geographical) settings. This will help to establish the generalizability of results. Although the focus of HCI has always been on user interaction, the field of HCI recently is contributing to designing new tools and techniques that improve usability [7]. Hence, OnPsyD Tool will be a unique knowledge contribution to the field of HCI and online Psychometrics.

Fig. 2. Database Design

6 Limitations

OnPsyD Tool has been designed as a research tool. Hence, currently, there is no intention to integrate data analysis capabilities (e.g. statistical data analysis). However, if required, this facility could be integrated later on. Further, no skip logic or branching rules for questionnaire items are implemented. If required, in future, the database, because it is extensible, will be able to accommodate this functionality.

7 Future Work

On successfully implementing and testing the OnPsyD Tool the plan is to extend the same to mobile technologies.

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