Rasch Analysis on Individual Cognitive Styles for Museum Learning Performances

Asmidah Alwi[1]

[1]*Universiti Utara Malaysia, Malaysia, asmidah@uum.edu.my*

ABSTRACT

The advantages offered by the web-based environment have successfully convinced museums around the world to employ the technology in enriching their visitors' learning experiences. However, the design and development of such environment in presenting the museum exhibits is challenging due to the complexities of human-computer interaction. The diverse profiles of museum visitors also add to the dilemma in designing effective museum leaning experiences for all. This paper addresses the issue by focusing on the effects between media representation formats and individual cognitive preferences. The data collected utilizing a quasi-experimental design was then analyzed using Rasch Model. The findings reveal that cognitive styles do have an effect on the learning performance thus should be consider during the design process of the learning environment.

Keywords:Media representation formats, cognitive styles, human-computer interaction, museum experience, web-based learning.

I   INTRODUCTION

The rapid growth of web-based technology extends the opportunity to fulfill museum exhibit facilitation. While the web-based environment continues to offer wide opportunities for effective learning, its design and development process is facing great challenges due to the diverse visitors' demographics factors. Consideration on museum visitors' cognitive differences for example, brought dilemma to the curators and designers when planning for their exhibits. This particularly reflected in the museums' information representation, where it is almost impossible to have a design that is fit for everyone (Schaller et al., 2007). Therefore, issues on the complexities of human-computer interaction remain to be explored, indicating that human differences have become significant challenges for the designers. Apparently, there are various guidelines, effective design formats and evaluation tools for web-based environment in the market. However, most of them tend to address the general issues of user interface design and usability rather than considering the individual user differences.

Recently, examining individual cognitive style has been a topic of interest for researchers when explaining user differences in the complexities of human-computer interaction. Many suggest that understanding human cognitive preferences is critical for the success of any web-based information system development (McCracken and Wolfe, 2004, Sharp et al., 2007). Grimley (2007) for example, concluded that cognitive styles, gender, working memory and prior knowledge have significant impact on web-based learning.

Cognitive styles is relatively a stable category of individual users difference (Granic and Nakic, 2010),has been described as *"an individual's preferred and habitual approach to organizing and representing information"* (Riding and Rayner, 1998) or put in other words, the way an individual processes the information they receive. Recently, there is a growing interest in pursuing research on cognitive preference, which demonstrated by the number of new studies in the web-mediated instructional environments. As most of these studies have been conducted in formal educational settings (Chen et al., 2006, Chen and Lui, 2008, Graff, 2003, Hannafin et al., 2009), this research hopes to add to the literature by examining an informal web-based educational environment.

To address the importance of accommodating individual differences in cognitive preference in the web-mediated museum environment, the discourse commences by introducing the online museums that are emerging as innovative web-mediated educational institutions. The discussion will then proceed with the two dimensions of cognitive style (Wholist-Analytic, Verbal-Visual) as described by Riding and Cheema (1991). The chapter continues with an outline of the research design, results and ends with a short discussion.

II   MUSEUM AS INSTRUCTIONAL SETTINGS

Museums have been well accepted as informal settingfor learning (Black, 2005; Falk and Dierking, 1992). There is also considerable literature that recognizes the use of museums in facilitating school-based education (Black, 2005, Falk and Dierking, 2002). Although the role of museums in supporting the formal education of the general population is usually associated with visits to a physical museum, online museum environments are now playing an important part in providing more information to people, as well as further enrich their life-long learning experiences. The literature shows that there is previous work in the museum context that has recognized the online environment as a 'cognitive space' in which a museum operates to deliver pertinent information and exhibit the artifacts. This new online role has also been highlighted in the definition of museum roles as defined by the Museums Australia Constitution in 2002.

Historically, the use of ICTs to enhance the museum learning experience started in the early 1990s. During that time, the potential of interactivity and multimedia were well considered (Schweibenz, 1998) and embedded in the delivery mode of museum exhibitions (Witcomb, 2007). Even the role of museums grows with the advent development of their ICT exhibiting tools, we see museums only taking advantage of these tools to record their collections in electronic databases or to embed the exhibition itself as an ICT artifact. Instead, we suggest that museums can play a more important role in facilitating the process of learning using the newest Web-based tools, which offer new learning opportunities (McKay, 2003).

However, due to the complexities of web-based instruction, questions are now being raised about how museums will embrace this dilemma through information and communications technology (ICT) tools to improve and better satisfy their visitors' learning experiences. In general, it would appear that museum curators try to design their interactive exhibits for a broad range of visitors. Consequently, the process of creating and implementing online learning and educational experiences has become a new adventure for museum curators. New directions include taking a learner-centric approach (Klevan and Kramer, 1999, Schaller et al., 2007) and user-centric development (Hsi, 2003, Paterno and Mancini, 1999).

III   WEB-BASED MUSEUM INFORMATION REPRESENTATION

The nature of web-based environment allows museum information representation formats to be presented in more than one modality. As researchers appear to have been primarily concentrating on combinations of text and pictures (Schnotz and Bannert, 2003), it could be seen that the museums apply such practice by using both verbal (text) and visual (images) in their exhibit display techniques. Example of a web-based museum information representation is depicted in Figure 1.
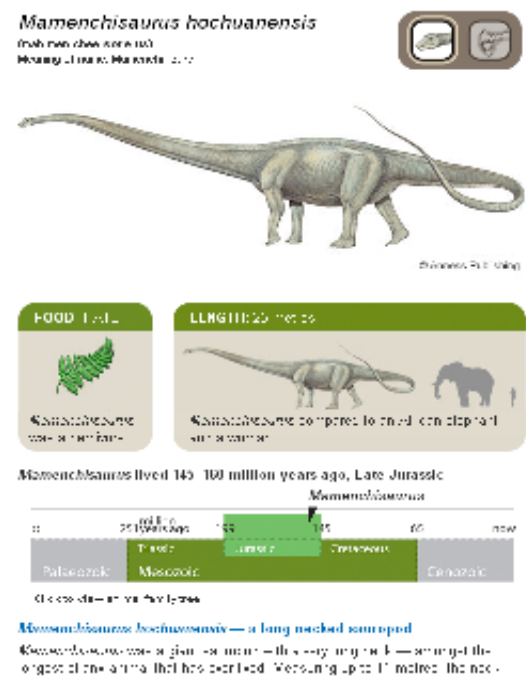

Figure 1. Combination of text and graphics in web-based museum information representation.

However, it is important to note that the way information represented may influence how individuals attend to appropriate pieces of the information (Kolloffel et al., 2009, Mendelson and Thorson, 2004) thus challenge both learners and designers. Additionally, Gagne (1985) asserts that learning is highly influenced by the environment in which the learning process takes place.

The use of multimedia instructions in the web-based museum intends to foster learning (Mayers 2009). However, many suggest that even professionally developed instructions have failed to achieve recognizable learning benefits (Spector and Davidsen 2000; Schnotz and Lowe 2003) since the potential of the technologies can only be realized if the design and use of the technologies are derived from the understanding of how the users learn

(Laurillard 2006; Leflore 2000). Furthermore, literature in the area of multimedia learning and instructional design suggests well-designed educational programs should consider both the human cognitive perspective and multimedia principles (Leflore 2000; Merrienboer and Kester 2005; Sutcliffe 2003). This argument is strengthened by the limited capacity of the human brain for information processing (Miller 1956), indicating that understanding human cognitive psychology is an important aspect when designing multimedia representation formats, particularly in online learning environments (Sorden 2005). Even so, there has been little or no consideration given to the interactive effect of the differences in cognitive styles (McKay 2003) and the exhibit's design, during the online exhibit designing process (Berry 2000).

IV COGNITIVE STYLES

Cognitive styles according to Riding &Rayner (1998) are a human psychological dimension that is *"integrally linked to a person's cognitive system"* (Peterson et al., 2009). Therefore, it could be accepted that each individual's cognitive style preference is unique and likely to be a fixed aspect of an individual's (cognitive) functioning (Riding and Rayner, 1998, Sadler-Smith and Riding, 1999). This assumes that an individual will *"learn differently and that these differences are identifiable and quantifiable"* (McEwan and Reynolds, 2007). As such, cognitive preferences are understood to be an individual's preferred and habitual approach to organizing and representing the information they receive, hence potentially provides *"an extensive and more functional characterization of students than could be derived from intellective abilities"* (Messick, 1984).

This study uses the two dimensions of cognitive styles as derived by Riding and Cheema (1991): the Analytic-Wholistic and the Verbaliser-Imager dimensions. The Wholist-Analytic dimension describes 'the way an individual processes their received information' for recall purposes whilst the Verbal-Imagery dimension denotes the information representation strategy an individual adopts 'during thinking about the information they receive' (Riding and Sadler-Smith, 1997).

Analytic-Verbaliser	**Analytic – Imager**
Wholist-Verbaliser	**Wholist-Imager**

Figure 2.Possible preferred combination of cognitive styles (Riding and Rayner 1998)

Based on these two dimensions of cognitive styles, a person's cognitive preference is anticipated to be one of four style groups (Figure 2), which are: analytic-verbaliser, analytic-imager, wholist-verbaliser or wholist-imager. Each of the four style group may have different basic preferences towards mode of instruction. As an example, learners who are from the analytic-verbaliser category may prefer text in contrast to those analytic-imagers who may perform better given a captioned picture or diagram. Therefore, it is likely that different individual with different cognitive preference will perform differently in a given context.

V EXPERIMENTAL DESIGN

As the online museum visitors are likely to emanate from the formal educational sector (Peacock et al. 2009), the data was collected from primary school students aged ten to twelve years old. The participants were selected from schools visiting the Dinosaur Walk exhibition at the MelbourneMuseum. As the students' prior knowledge was considered in the research experiment, students in a particular group were anticipated to share similar backgrounds and to have received the same level of educational experience as others of the same group. By employing a quasi-experimental design, each individual group has been tested as a whole 'population' to avoid underestimates and statistical errors during the data interpretation.

The fieldwork experimental design has three phases (in the primary schools and the museum). The first phase involved a screening test to measure the participants' cognitive preferences, using the cognitive style analysis (CSA) (Riding 1991) screening test. The CSA and a pre-test to determine the participant's prior domain knowledge related to the museum exhibits were conducted prior to the museum visit. Based on the cognitive preferences identified from the CSA, participants were equally split into the treatment groups, either the online

museum or the physical museum visit treatment group.

In the second phase, the treatment groups were given access to either the online museum or the physical museum treatment respectively. For the online session, participants were given 30 minutes to browse the existing web pages of the Dinosaur Walk exhibition in the MelbourneMuseum website. Meanwhile, participants of the physical visit treatment group were taken to explore the Dinosaur Walk exhibition in the MelbourneMuseum within the same length of time. The final research phase was a post-test to measure any improvement in the cognitive performance (or learning outcomes) derived from the museum's learning exhibits which was conducted at the end of the museum visit.

VI   ANALYSIS AND RESULTS

The data gathered from 91 participants using the pre test and post instruments was then analysed using the Winstep Software that applies Rasch Measurement Model. The model that is probabilistic and inferential allows analysis of an individual performance relative to the instrumentation as "*the person ability and item difficulty are conjointly estimated and placed on a numerical scale*" (Sick 2008) called logit. A logit is a unit of measurement described as "interval scale in which the unit intervals between locations on person-item map have a consistent value or meaning" (Bond and Fox 2007) or referred as uni-dimensionality. This occurs when the data fit the model and reliability of item placement is established.

This paper will only discuss on the analysis conducted on cognitive styles. The analysis was conducted on single cognitive styles dimension (CSD) that differentiate between wholist-analytic and verbaliser-imager dimension. The analysis was then extended to the combination between the cognitive style dimensions: wholist-verbaliser, wholist-imager, analytical-verbaliser and analytical-imager.

The mean analysis indicates that general performances of participants in Treatment 2 (T2) are better with mean score of 43.0 as compared to Treatment 1 (T1) with mean score of 39.1. When comparing general performance of CSD in between treatments, the results shows that each CSD demonstrates a better performance in T2. Further analysis of CSD in T1 reveals that verbalisers record the highest mean score of 39.9 whilst

wholist mean score is slightly lower at 39.5. Analytics and imagers are found to be at par in their performance with mean score of 38.6 and 38.5 respectively. Analysing the result of CSD in T2 shows that all CSD have improvement in their mean score in T2. However, this time, analytics achieved the highest mean score t 44.8. Verbalisers that previously scored the highest are now revealed to be the least score at 42.6. This analysis is simplified in Figure 3.

As for the analysis of CCS, the general results show that out of the four CCS, Analytic-Verbalisers and Wholist-Imagery achieved levelled performance at 41.8 and 41.7 respectively. Wholist-Verbaliser mean score is 40.9 whilst Analytic-Imagery scored the least at 37.3. Analysis of CCS for each treatment provides further details of their performances.
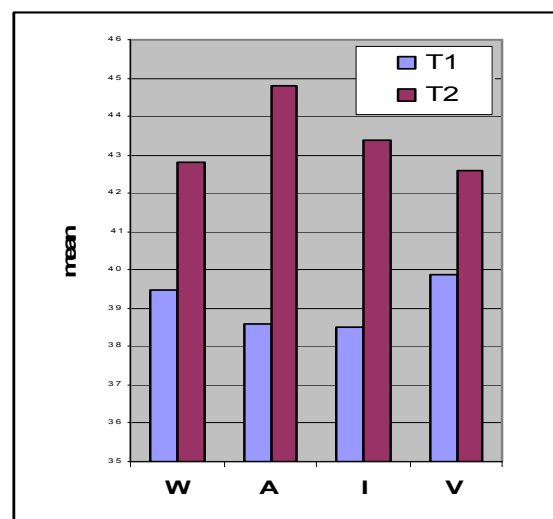

Figure 3. Analysis of CSD according to treatment.

For T1, Analytic-Imagery found to have the least mean score of 35.7 whilst Analytic-Verbaliser with the highest mean score of 40.4. As for Wholist-Verbaliser and Wholist-Imagery, their performances are almost equal with mean score differences of 0.2 only. Analysis for T2 shows that Analytic-Verbaliser remains the top scorer while Wholist-Imagery performs better than Wholist-Verbaliser. Interestingly, Analytic-Imagery demonstrates significant improvement with differences of 7.3 between T1 and T2. This result is depicted in Figure 4.
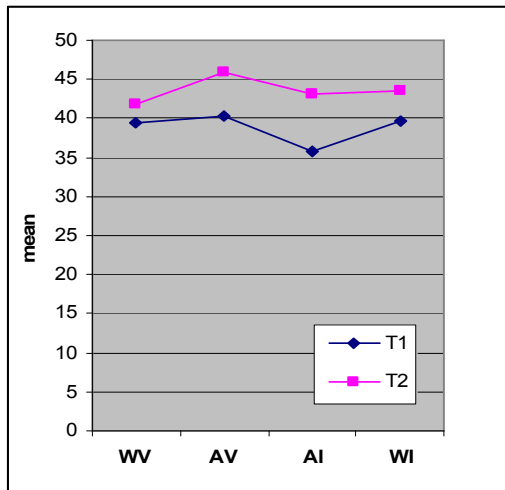
Figure 4. Analysis of CCS according to treatment.

VII   DISCUSSION

This paper aims to explore the effects of cognitive styles namely the verbaliser-imagery and wholist-analytics dimensions on museum learning experience. The research was conducted by focusing on the web-based museum exhibits whilst comparing it with the physical museum exhibits for Dinosaur Walk museum exhibition.

The analysis was conducted in two ways, first by comparing between single cognitive style dimensions (CSD) and within the combined cognitive style dimensions (CCS). For the analysis of CSD, the results demonstrate that wholists' performance is better than analytics in T1, or the web-based museum exhibit environment. However, the results were vice versa in T2 whereby analytics achieved higher mean as compared to wholists. The same pattern was also observed for verbaliser-imagery dimension where imagers' performances increased in T2 whereas;verbaliser shows a decline in the mean score in T2. Further analysis on means of both CSD reveals that both dimensions have an interaction with the different formats of museum exhibits therefore suggest that cognitive styles do have an effect on museum learning performance.

On the other hand, analysis on CCS reveals that wholistswith preferences in either verbal or imagery have similar performance with slight differences. This could suggest that wholists whom presumably process information they receive as a whole (Riding and Cheema, 1991) have benefitted the combination of text and graphical information in the web-based museum environment, despite their verbal or visual preferences. However, there is a significant difference for the analytics. From the result, it is shown that analytics with verbal preferences performed the best whilst analytics

with visual preference performed the worst. This could be an indicator that analytics may outperform wholists in web-based museum learning performances when they are verbaliser.

The way information presented in the physical museum (scattered individually as objects or individual exhibits) allows analytics to process the information in chunks(Riding and Cheema, 1991) hence perform better than wholists. Whereby, the combination of both textual and graphical information in the web-based museum gives more advantages to verbalisers than imagers. However, both textual and graphical information displayed together in the web-basedmuseum exhibit may also distort the focus and concentration of the imagers. Besides, as some of the information is displayed in either text or graphical only, could possibly cause imagers to focus more on the images and miss some of the verbal information.

Both analysis in CSD and CCS demonstrates that Imagers have lower performance in T1 as compared to verbalisers. This therefore suggests that findings from this research arecontradicted to the previous findings (Parkinson and Redmond, 2002; Riding and Douglas, 1993) when they suggest that Imagers should perform better with combination of text and graphics in a learning environment when compared to verbalisers. However, the premise remains true for the physical museum exhibits.

Based on the results, it can be concluded that web-based museum exhibits using the combination of both textual and graphical information could benefits both wholists and analytics. However, the nature of the web-based information representation with such combination may provide more advantages to verbalisers than imagers. This paper only reports the comparison between the instructional strategies of the museum exhibits (web-based and physical museum exhibits). For future work, it would be interesting to explore further in other the web-based environment. Factors such as the use of frame or information structuring and other interface design issues are likely to interact with cognitive styles when affecting the learning performance. Additionally, involving users during the design and development or evaluation process of such learning environment may also provide richer information and detail understandings.

VIII CONCLUSION

The emerging web-mediated technology tool isemphasizing the use of multimedia. Therefore, there is an understandable increased expectation for virtually orientedmuseum exhibition. These web-based environments integrate both visual and verbal instructional formats. As people have their own cognitive preferences, attention should be given in the design and development of such learning environment particularly on the information representation formats. This is to cater the broad range of human cognitive abilities (McKay, 2003). Finally, findings from this study may either serve to inform the design and development of the web-based museum exhibits or for evaluation purposes. On the other hand, the findings could also be utilized in planning for information representation and media formats in other web-based learning environment.

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