ISSN: 2394-7659
IMPACT FACTOR- 2.789

International Journal of Engineering Researches and Management Studies

UNDERSTANDING CHILDREN'S LEARNING FROM MULTIMEDIA INSTRUCTION MODEL

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ABSTRACT

The use of multimedia instructions for online learning has become very common particularly with the advances of the Internet technology. Consequently museums around the world utilize such information and communications technology (ICT) tools in order to provide richer learning experiences for their visitors. This paper discusses a study that investigated the relationship between multimedia instructional formats with individual cognitive learning preferences in a museum learning environment. A total of 91 school children age between 10 to 12 years old were randomly assigned into treatment groups based on their cognitive learning ratio. We employed a pre-test post-test quasi experimental design to reveal that general performance of the children exposed to the physical museum exhibits is better than the online museum environment. Although single cognitive learning preferences were evaluated, our findings suggest that analytics perform better than the who lists when exposed to the physical exhibits; whilst the result is reversed for the online exhibits environment. Verbalises were found to be better than visualises in the physical a museum context. Yet they were found to have slight differences when compared to visualises in an online environment. Our findings on the combined cognitive styles (CCS) show that the analytics-visualises mean scores were different between physical and online exhibits, compared to the other three CCS.

Keywords: Multimedia instructions, cognitive preferences, museum learning, web-based learning.

I. INTRODUCTION

Multimedia is simply defined as the use of text, graphics, animation, audio and video to present information. The revolution of the Internet and the communication technologies has foreseen the information to be delivered or made available in computer-based instruction utilizing multimedia. Combination of these media or better referred as multimedia instructions allows information to presented in a better way as compared to information dissemination in a single format. As suggested by Mayer (2009) and Schnotz and Lowe (2003), learning from multiple formats of instructions presumptively resulted in a better learning outcome as opposed to learning from a single format instruction. Nevertheless, there are research that proven otherwise (for example: Rasch & Schnotz 2009), hence the proposition remain inconclusive. Additionally, review of literature shows that in order to gain a more holistic understanding about how multimedia instruction could support learning, some other factors pertaining to the learning process such as the learning environment, learners' characteristics as well as institutional and administrative aspects should be considered when investigating the effectiveness of such learning instructions (Tallent-Runnels et al. 2006). Web-based learning, which involves ICT multimedia tools, has emerged to overtake the more traditional forms of instructional environments. In doing so however, the increased adoption of this alternative pedagogical regimen may raise questions to doubt its effectiveness, such as: does the combination of different media really work in such learning environments?; which combination works and with whom?; and many other questions that will require answers. Research has also shown that not every instructional format works for everyone. Schnotz (2008) and Kollöffel (2012) for example, suggest that effectiveness of animation when used as an instructional format depends on factors like: learners' preferences towards verbal or visual in format; prior domain knowledge; and other learners' personal learning characteristics. This dilemma suggests that other factors may be playing a part. Therefore learners' characteristics should be closely taken into account when designing multimedia instruction strategies. Obviously, it requires concentrated attentions that are caused by the human-computer interaction (HCI). The diversity of learner characteristics forces careful consideration to address an individual's specific learning requirements. Children for example, have their own perceptions towards receiving their learning instruction given to them through multimedia. Previous research, which focused on children's performance when learning from multimedia instruction, indicated there were elevated promises afforded by such ICT tools. However, the findings remain inconclusive (for example see: Grimley 2007; Silverman & Hines 2009). This disparity is due to the other

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factors or other learner characteristics, which should be taken into consideration, when designing for multimedia learning environments. Herewith, we are suggesting that investigating the way people process their information may provide a deeper understanding of the effectiveness of ICT multimedia tools which adopt such instructional pedagogies in helping the instructional/learning process. Individual cognitive learning preferences, as such depict which is their preferred and habitual approach to organize and represent the instructional information they receive. This characteristic potentially provides *"an extensive and more functional characterization of students"* (Messick 1984). Cognitive style is a human psychological dimension that is integrally linked to a person's cognitive system (Peterson, Rayner & Armstrong 2009), whereby it is unique and likely to be a fixed aspect of a person cognitive functioning (Riding & Rayner 1998).

In the cognitive psychology field, several cognitive style models have been developed. However, it should be noted that they have been derived from researchers' perspectives and varied contexts. Hence in attempting to settle on one definition, it widens the scope and becomes very confusing. Riding and Cheema (1991) consolidated and categorized these various cognitive styles models into two dimensions: the wholist analytic and verbalizer-visualizer dimensions. The wholist-analytic dimension describes the way an individual processes the information they receive, whilst the verbal-visual dimension explains the information representation strategy an individual adopts as they think about the information they receive (Riding & Sadler-Smith 1997).

The cognitive styles model suggested by Riding has given rise to a computerized testing tool called the Cognitive Styles Analysis (CSA) system. The CSA is used to assess a person's position on the continuum for both wholist-analytic and verbal-visual dimensions, based on the computer-generated ratio. Despite the critics on its reliability (Peterson, Deary & Austin 2003), the CSA remains to be one of the most systematic and useful tools to identify a person's cognitive (learning) preferences. The CSA has been used by researchers for many years. Based on the two (Riding) dimensions of cognitive style, a person's cognitive preference is anticipated to be one of four style groups: analytic-verbaliser; analytic-visualiser; wholistverbaliser; or wholist-visualiser. Each of the four style groups may have different basic preferences towards mode of instruction. Based on this catagorization, a learner from the analytic-verbaliser category may prefer text in contrast to those analytic-visualisers, who may perform better given a captioned picture or diagram. Therefore, it is likely that different individuals with different cognitive learning preferences will perform another way in another instructional context.

Based on the arguments discussed above, this research was conducted to investigate the interplay between multimedia instructions offered in a web-based museum learning environment and the learners' cognitive style preferences. This paper provides the context of investigation as well as explaining the experimental design. The findings will be discussed based on the results of the single cognitive preference dimension (CPD) and the combination of the full Riding cognitive style dimensions (CCS).

II. CONTEXT OF INVESTIGATION

Many museums around the world have now ventured into the web-based environment. Consequently, it is pertinent to investigate the effectiveness of multimedia ICT tools that are being used to provide richer museum learning experiences for their visitors. This investigation foreshadows an innovative transformation of the instructional/learning environment; in conjunction with the more traditional role a physical museum plays in facilitating a formal learning experience. Furthermore, acceptance of web-based museums as being a medium of communication and shared information is now seen more as contributing to acknowledgement that museum institution supports such transformation. To this end, museums are taking the advantages afforded by the web-mediated ICT tools to enhance their communication and educative interactions. These digital pedagogies support the physical museum experience, thus creating a new dimension for their visitors' affective experiences. The museum's role as a communication medium has long been recognized (Lord 2007). Hence, the use of multimedia instructions in the web-based museum is intended to boost the information delivery whilst foster learning (Mayers 2009).

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However, many suggest that even professionally developed instructions have failed to achieve recognizable learning benefits (Spector and Davidsen 2000; Schnotz and Lowe 2003). This heightened museum's communication role cannot be seen only as the process of delivering information; it also delivers knowledge acquisition opportunities to suit the museum's educational aims and objectives. The opportunities offered by the web-based environment may provide a wider (cognitive) space for online visitors in their information processing (or meaning making). As a result it is important to note here that it is the way information is represented influences how individuals attend to appropriate pieces of information (Kolloffel et al. 2009; Mendelson & Thorson 2004) that challenges both learners and designers. The fact that learning is highly influenced by the environment in which learning takes place (Gagne, (1985) has been reflected in the contextual model of museum learning (Falk & Dierking 1992; 2000), The situation in which the role of context is emphasized, contemplates that learning is a process occurring under certain instructional conditions, with the effects likely to vary among individuals (Gagne 1985). However, it is important to differentiate between learning and instruction, as learning theories explain what happens in the learner's head whilst instructional theories describe the conditions which facilitate learning (Reigeluth 1983). There are extensive changes in the supporting technologies available, whilst enriching the museum learning experience. It could be argued that the potential of such technologies may only be realized if the design and use of the ICT tools are designed and developed drawing upon our understandings of how the users learn Laurillard (2006).

It is with this background that this research project was conducted on an exploration of students' learning experiences in an online museum environment. The research aim was to investigate the relationship between the museum's ICT enhanced (multimedia) instructional strategies with students' cognitive learning preferences in their museum learning performance. There is still much to be discovered about how learners interact with multimedia enhanced instructional strategies online. Exploring the learners' individual cognitive preferences provides an insight of their working memory during the learning process hence afford a better understanding of the relationship between the two factors. This increased understanding will assist to identify the instructional conditions, which enable and facilitate, rather than hinder the learning process

III. THE EXPERIMENTAL DESIGN

There were 91 schoolchildren age 10 to 12 years old chosen to participate in this research. They visited the museum (brought there on a special but, by their teachers as an educational field trip). They were to learn from a certain exhibit that related to what they would be expected to learn in their classroom setting. This group of children were recruited using a convenient sampling technique from three schools. Their prior knowledge was considered in the experiment's design. They were anticipated to share similar familial backgrounds and to have received the same level of educational experience as others of the same group. The fieldwork-experiments employed a three-phase quasi-experimental design. The first phase involved a screening test to measure the participants' cognitive preferences, using the CSA (Riding 1991) screening test. The CSA and a pre-test were conducted prior to the children's museum visit. The purpose was to determine their prior domain knowledge as it related to the forthcoming museum exhibits. Based on the cognitive preferences identified from the CSA, the participants were assigned into the treatment groups; the children were given either the web-based museum instruction (T1) or the physical museum visit as their treatment (T2). Despite the distinctively different environments for T1 and T2, the multimedia instructions were the same (besides some other parts of the web-sites that offered instruction in other instructional formats such as video). Due to that disparity, for the purpose of this experiment, the T1 participants' access to the online exhibits was limited to the digital (computerized) instructional parts that replicated the instruction in the physical museum only treatment (see explanation in Figure 2).

In the second phase, each treatment group was given access to the online museum or the physical museum treatment respectively. For the online session, 30 minutes was allocated to the participants to browse the existing web pages of the Dinosaur Walk exhibition in the Melbourne Museum website (Figure 1). Meanwhile, participants of the physical visit treatment group were taken to physically explore the Dinosaur Walk exhibition (for

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example, see Figure 2 and Figure 3) in the Melbourne Museum within the same length of time. The experiment was concluded with a post-test given to the children immediately after receiving their T1 and T2, to measure any improvement in the cognitive performance (or learning outcomes) derived from their museum visit as learning experience.

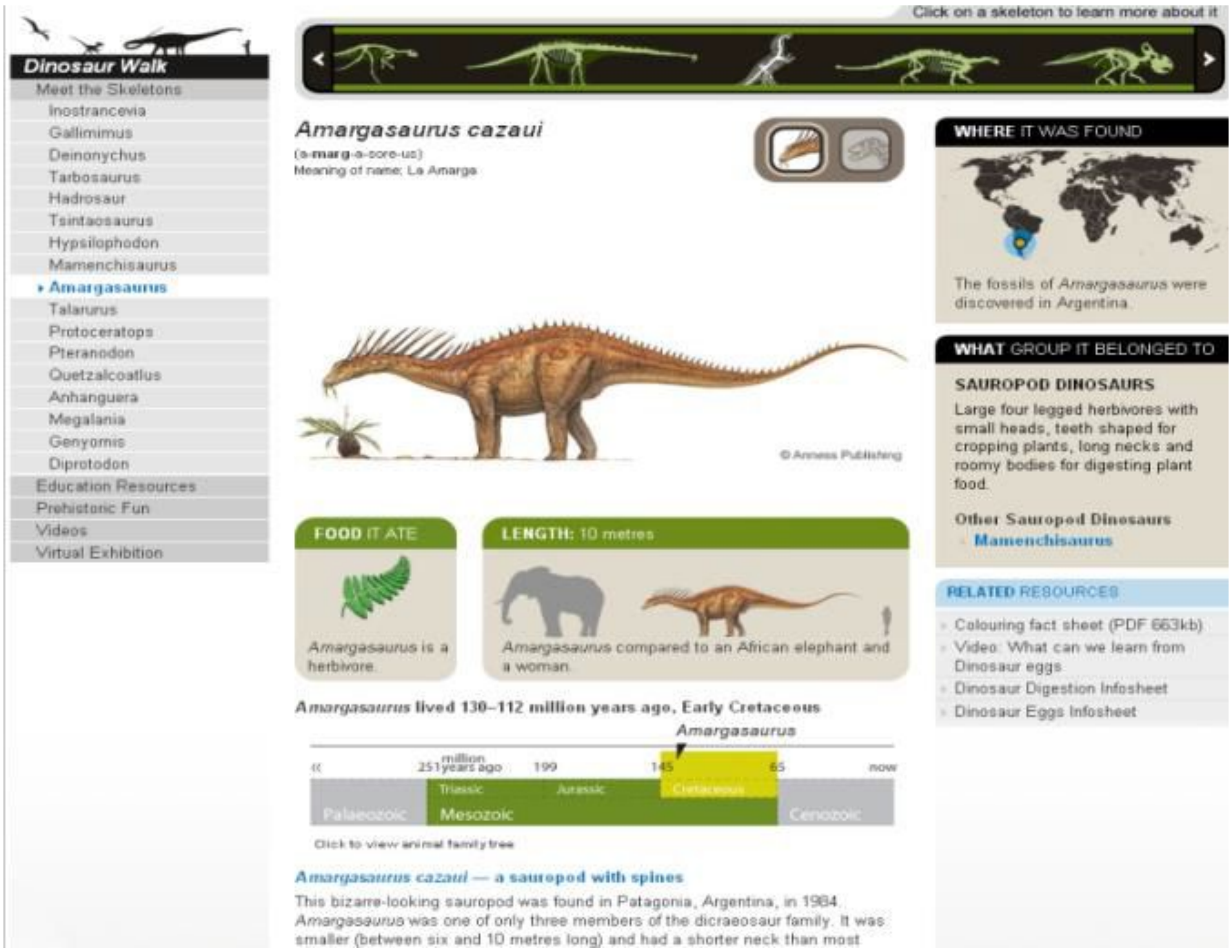
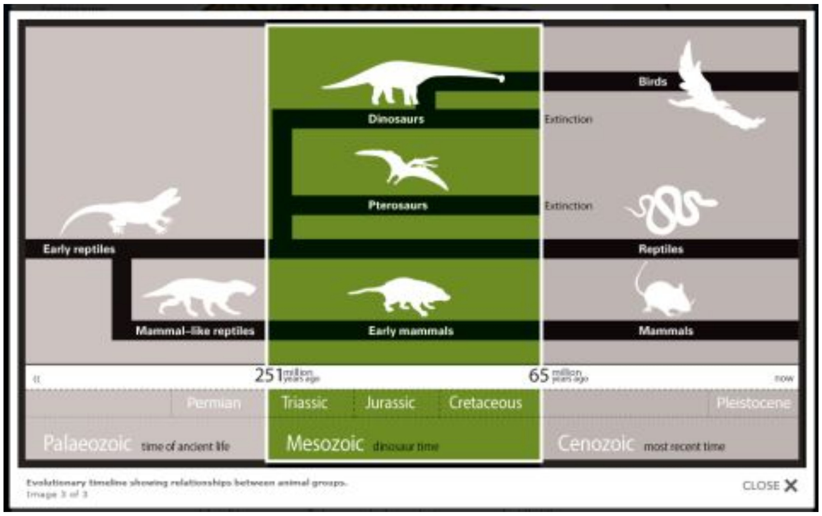


Figure 1. A page consists of the information of a dinosaur (courtesy of Melbourne Museum).

The instruction consists of text and graphics on display in the physical museum.



The same instruction on the website.

Figure 2. Example of exhibits display in the physical museum exhibition.

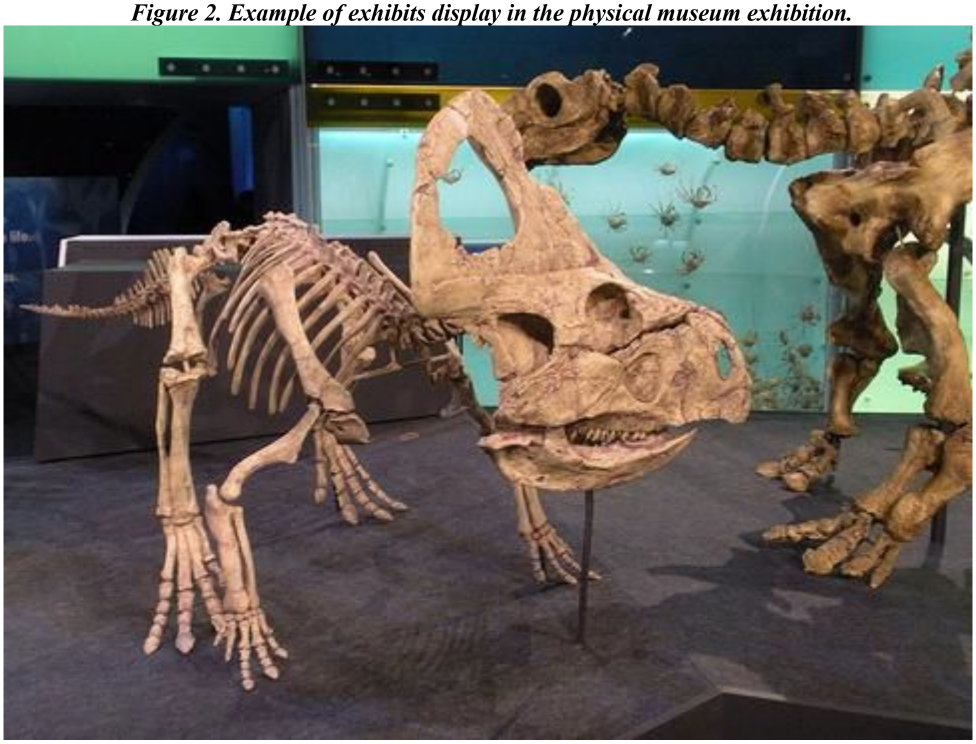


Figure 3. Dinosaurs' skeleton on display at the physical exhibition.

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IV. ANALYSIS & RESULTS

The data gathered from the fieldwork experiment was then analysed using the Winstep Software that applies Rasch Measurement Model. The model is probabilistic and inferential therefore 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.

The data analysis discussed in this paper was conducted by looking at the single CPD values that differentiated between the wholist-analytic and verbaliser-imager dimensions; extending to the combination of the CCS described earlier as: wholist-verbaliser; wholist-visualiser; analytical-verbaliser and analytical visualiser.

The analysis of mean score intends to identify the relationship between the cognitive styles and the multimedia instructions with students' learning performances for each treatment respectively. To do this, the mean score for the specific CPD and CCS was compared within and between treatment groups in order to identify the relationship.

In general, the mean analysis indicated that the overall performance of participants in T2 were better, as compared to those in T1 for both CPD and CCS. For CPD, the result yields a mean score of 43.0 for T2 over T1 with mean score of 39.1. When comparing general performance of each CPD in between treatments, the result was consistent with the earlier analysis which indicated that each CPD (wholist, analytics, verbaliser and visualiser) demonstrated a better performance with the T2. Further analysis of CPD in T1 revealed that the verbalisers recorded the highest mean score of 39.9. Whilst the wholist mean score was slightly lower at 39.5. Analytics and visualisers were found to be at par in their performance with a mean score of 38.6 and 38.5 respectively. Analysing the result of CPD in T2 shows that all CPD had higher mean scores in T2.

Nevertheless, the highest score was obtained by analytics with mean score of 44.8. Verbalisers that previously scored the highest in T1 were revealed to have the least mean score at 42.6. Overall analysis of CPD showed that analytics performed better than wholists in T2; yet the results was vice versa with T1. As for the verbaliser-visualiser dimension, the verbalisers achieved better scores with the T1, compared to the visualisers. However, both the verbalisers and visualisers' mean scores were found slightly differ with the T2. This analysis is simplified in

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Figure 4.

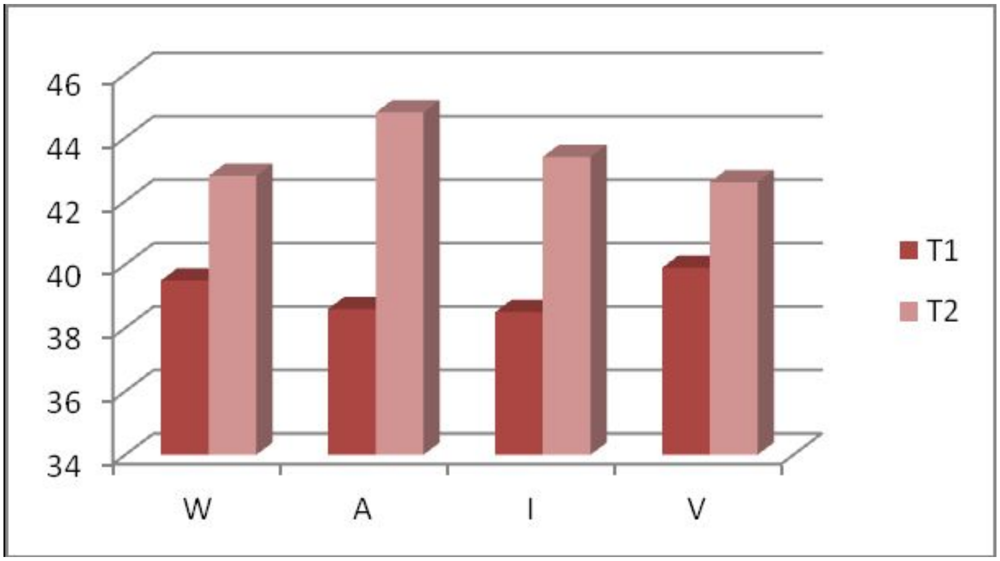

Figure 4. Mean score analysis of CSD according to treatment

Further analysis was conducted for CCS. In general it resulted showing that the analytic-verbalisers and wholist-visualiser achieved leveled performances with mean scores of 41.8 and 41.7 respectively. Whilst the wholist-verbaliser mean score was 40.9; the analytic-visualiser scored the least at 37.3. Analysis of CCS for each treatment provided further detail of their performances. For T1, the analytics-visualisers were found to score the least with a mean score of 35.7; whilst the analytics-verbalisers demonstrated that their highest ability was to score at the 40.4 level. The wholist-verbaliser and wholist-visualiser performed equally well with mean score differences of only 0.2. The mean scores analysis in T2 revealed that the analytics- verbalisers group remained as the top scorers. On the other hand, wholist-visualisers performances were better compared to the wholist-verbalisers with mean score differences of 1.6. Interestingly, analytics visualisers recorded a difference of 7.3 when compared with the mean scores in T1. The overall result for the CCS is depicted in Figure 5.

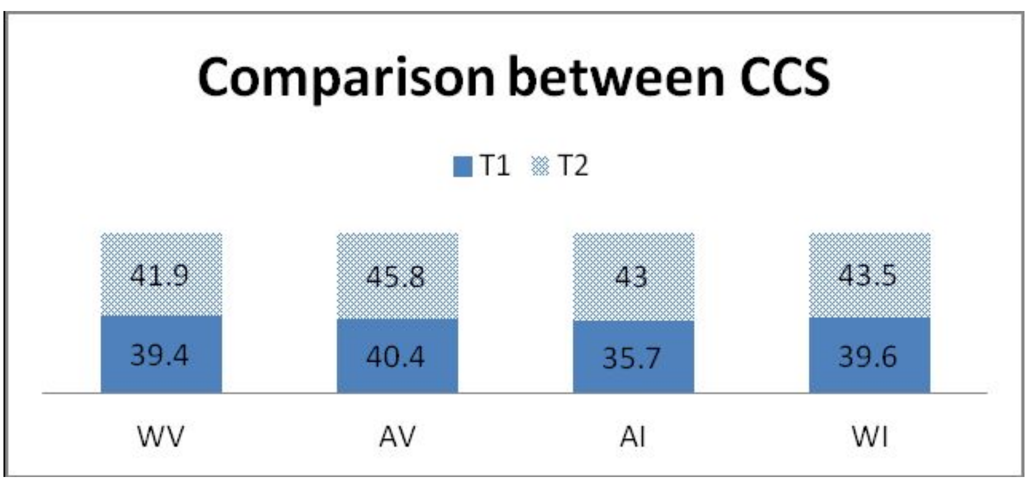

Figure 5. Mean score analysis between CCS according to treatment

V. FINDINGS & DISCUSSIONS

The aim of this paper aims was to explore the effects of cognitive learning preferences; namely the verbaliser-visualiser and wholist-analytics dimensions on children's museum learning experiences. The research was conducted by focusing on the web-based museum exhibits whilst comparing them with the physical museum exhibit for the Dinosaur Walk exhibit. The data analysis was conducted in two stages. The first was by comparing between single CPD and within the CCS. For the analysis of CPD, the results demonstrate that wholists' performance was better than the analytics with T1 (the web-based museum exhibit environment). However, the results were vice versa with the T2; whereby the analytics achieved higher mean as compared with the wholists. The same pattern was also observed for the verbaliser-imagery dimension, where the imagers' performances increased with T2. Whereas, the verbalisers showed a decline with their T2 mean score. Further analysis on the means of both CPD revealed that both dimensions had an interaction with the different instructional museum exhibit formats; therefore suggesting that cognitive learning preferences do have an effect on museum learning performance.

On the other hand, the CCS analysis revealed that the wholists with preferences in either the verbal or imagery dimension, have similar performances with only slight differences in their mean scores. This result suggests that the wholists, whom presumably process information they receive as a whole (Riding and Cheema, 1991), benefited from the combination of text and graphical information in the web-based museum environment; despite their verbal or visual learning preferences. However, there was a significant difference for the analytics. From these results, it was shown that the analytics with verbal preferences performed the best, whilst the analytics with a visual preference performed the worst. This result indicated that the analytics

outperformed the wholists in their web-based museum learning performances when they were a verbaliser. The way information is presented in a physical museum (scattered individually as objects or individual exhibits) allows analytics to process the information in chunks (Riding and Cheema, 1991). Hence they perform better than the wholists. Whereby, the combination of both textual and graphical information received in a web-based museum gave more advantages to children who were verbalisers than the visualisers. As suggested by Kim and Gilman (2008), reduced amounts of screen-based text provide ample space for graphical instruction that assists certain learners to understand better. However, combination of both textual and graphical instructions displayed together in a web-based museum exhibit may also distort the focus and concentration of the visualisers; conforming to the findings by Schnotz, Bannert and Seufert (2002). Besides, as some of the information was displayed in either text or graphical format only; this may possibly cause the visualisers to focus more on the images and miss some of the verbal information.

Both the CPD and CCS data analysis demonstrates that the visualisers had lower performances with the T1 as compared to the verbalisers. This result therefore suggests that findings from this research are contradicting the previous findings of Parkinson and Redmond (2002), and Riding and Douglas (1993), when they suggested that the visualisers should perform better with combination of text and graphics in a learning environment when compared to the verbalisers. However, the premise remains true for the physical museum exhibits

VI. CONCLUSION

This study investigated the effectiveness of multimedia instruction strategies that contained text and graphics, in delivering museum information, particularly in a web-based exhibit environment. A comparison was made to the traditional museum exhibits that offer similar information using the same multimedia instructional formats. Obviously, general performances of the participating children were better in the physical museum context when compared to the web-based museum environment. This finding indicates that a web-based learning space is useful; yet the traditional learning context remains as the most important. Based on the results discussed earlier, it can be

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concluded that web-based museum exhibits using the combination of both textual and graphical information benefits both wholists and analytics. However, the nature of the web-based information representation with such combination may provide more advantages to verbalisers than visualisers. Nevertheless, 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 web-based environments. Factors such as the use of frame or information structuring and other interface design issues that are likely to interact with cognitive learning preferences to affect the instructional/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.

Apart from that, the study also revealed that children with certain cognitive preference may perform differently (in physical and web-based museum environment). This result has resulted from the way they process the information they receive. Whereby a verbalizer was assumed to perform better when given textual instruction and imager should achieve better when dealing with a graphical instructional strategy. However, when it comes to multimedia instructions that combine both text and graphics, the findings could be different depending on the context of investigation. As discussed earlier, this study demonstrated that the combination of text and graphics gave more advantages to verbalizers than visualisers. Looking at the wholists-analytics dimension, the findings revealed that the wholists preferred the physical museum exhibits, compared with a web-based exhibit; whilst the analytics performed better in the web-based museum setting. The overall conclusion that is drawn here is; it is necessary to have a good understanding of the relationship between multimedia instructional formats to be offered (in facilitating the learning process) with the way learners perceive the instructional information. To do so, an investigation may be essential to provide a deeper understanding of the learning settings as each is unique and may be different from other learning environment. Furthermore, those findings from other research could be helpful in guiding the design of a learning environment. Yet specific consideration of that particular context will provide more explicit understandings towards designing more effective instructional/learning strategies. Furthermore, this study also demonstrated the importance of allowing for learners' cognitive learning preference differences when designing multimedia instruction. This means to cater for a broader range of human cognitive abilities (McKay 2003).

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