

Integrating Learning Style in the Design of Educational Interfaces

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Abstract

Understanding learners' characteristics and behaviour using hypermedia systems in education is still a challenge for most developers and educators. This study seeks to understand the influence of learning style on learners' use and preference of a Computer Based Learning (CBL) program which was developed using two navigational structures (linear and non-linear). The study presents the findings of a case study conducted in Kuwaiti Higher Education. Data analysis was used to understand learners' needs and perceptions in using navigational structures. The relationship between learners' needs, learning styles, perceptions, and preferences in using the CBL program in regard to learner's gender is discussed in this paper. We found that both males and females liked to see the two navigational structures in the CBL program. Moreover, we found that although males and females are both prefer using the non-linear structures, the data analysis shows that males actually used linear structures of the program and they are characterized as verbalized, field independent and serialist learners. Females, on the other hand, need to use the non-linear structure, and characterized as visualized, field dependent, and holist learners. It is interesting to find that learners (both males and females) may use specific navigational structures (linear and non-linear) accommodated in a CBL program although it may not be what they prefer.

Keywords: *e-Learning, HCI, learning style, Individual differences, ICT, Hypermedia*

1. Introduction

Opportunities and challenges are emerging for learners, teachers and institutions from the increasing implementation of Information and Communication Technology (ICT) and associated infrastructure. However, designing and development an efficient educational interface within a learning environment is still a challenge for most developers, facilitators, and educators due to the complex understanding of learners' characteristics and behavior that incorporates many pedagogical and technological elements. The computer human interaction (CHI) environment regularly researches factors that affect the success or failure in interaction with computers.

The rapid developments in ICT and the evolving learner characteristics and behaviours require continuous effort to design digital content, both in the physical and virtual 'classroom' spaces [1]. The implementation of ICT has become standard in all aspects of life, including the field of education. Educational institutions, educators, and researchers are calling for providing educational materials that is informative, well designed, with consideration of

learners' characteristics and style [2]. There have been numerous research studies on learning style's effect on learners using ICT in teaching and learning. Learners' preferences, perception, and their ability to understand educational programs are determined by their varying skills and abilities.

Learners' performance, perception, and their ability to comprehend course content are determined by their varying skills and abilities. Individual differences such as gender, socio-cultural, and cognitive style may also affect learning motivation and performance. Such differences, known as individual differences of learners, have been found to be important factors to consider in the development of digital learning systems [3].

It is generally accepted that there are individual difference between learners in terms of perceiving, remembering, processing, organizing information and problem solving [4]. It is important that instructors are able to recognize information resources that match learner's needs. In addition, learners should have a flexible interface that accommodates their learning styles, individual preferences, and should also be able to easily identify relevant content and navigation support. In Guo & Zhang, 2009, a framework of individual computer- based learning systems focuses on the learner's cognitive learning process, learning patterns and activities, and the technology support needed. This if properly designed by considering learners' individual differences will provide sufficient learning resources and communication tools to build a collaborative learning environment where both students and instructors gain significant benefits. Gülbahar and Alper (2011) [5] stated that Learning preferences and learning styles are a way to enhance the quality of learning. They stressed that student can adapt learning processes, activities and techniques, if he/she is able to understand his/her own personal characteristics and the consequences of possible different experiences.

The central theme of this research paper is to understand the influence of learning style on learners' use and preference of an interactive Computer Based Learning (CBL) program which was designed and developed in a structure of different navigational structures (linear and non-linear access). The study presented in this paper was conducted on Kuwaiti Higher Education students in Kuwait.

The rest of the paper is organized as follows. In Section 2, we present previous related works which elaborate on individual differences of learners. Section 3 describes the methodology used to conduct the study. Results are discussed in Section 4, and Section 5 concludes the work presented in this study with future work.

2. Individual Differences of Learners

Previous studies demonstrated the importance of individual differences as a factor in the design of computer-based learning. Such individual differences have significant effects on user learning in computer-based learning, which may affect the way in which they learn from and interact with hypermedia systems. Tailoring the process of instruction to match learners' style and to reflect individual differences of learners is a strong challenge under the conditions of the ICT supported education. [2].

Rurato & Borges Gouveia (2014) [6] stressed that when providing educational instruction that takes into account different issues of learners such as: personal and professional life; available technology resources; motivation and learning preferences; will allow to both learners and facilitators the proper way to adopt learning strategies easily, and in turn, enhance the possibility of making the learning experience successful.

Chen (2002) [7] indicated that a non-linear learning approach in hypermedia learning systems may not be suitable to all learners. Learners may have different backgrounds, especially in terms of their knowledge, skills, and needs, so they may show various levels of engagement in course content. Therefore, many studies argue that no one style will result in better performance. However, learners whose browsing behavior was consistent with their own favored styles obtained the best performance results. Individual differences may also affect learning motivation and performance. Such differences of learners have been found to be important factors to consider in the development of digital learning systems. The following sections discuss individual differences of learners such as gender differences; learners' culture; and cognitive styles of learners.

2.1. Learner's Gender

Gender differences are also argued as an important factor that significantly impacts learning in hypermedia learning systems [8]. Studies show that, in general, females have less experience with computers than males [9]. Thus, females tend to experience more disorientation in hypermedia than males [10], and males have been found to outperform females [11]. Several studies also examined gender differences in perceptions of computers and the Web and found significant differences. Male users had more positive attitudes towards computers and the web compared to female users [9]. Conversely, there are studies indicating that there are no gender differences in attitudes

towards computers. Young and McSporran (2001) [12] examined gender differences in user learning performance in a hypermedia learning system and found that females favored and performed better with online learning courses. A study conducted by Atan, et al. (2002) [13], indicate that female distance education learners participate equally with their male counterparts in the utilization of computer technology to assist their study requirements as well as in their involvement in information and communication technology (ICT) to support the educational and learning process. Still, other studies have argued that there are no gender differences [14].

2.2. Learner's Culture

Understand ethnicity in different societies, the cultures of different generations, religion, education and literacy and language will undoubtedly help to successfully develop any product. Technology developers unfortunately concentrate solely on economic influences, assuming that the world that is becoming more globalized, however the continuing effect of local culture is present.

Designers of multimedia interfaces should be aware of the cultural features of the program in which it is important to have a mechanism to understand the cultural elements of the target user. These mechanisms are needed not only to provide "good" cultural interfaces to learners across multiple cultures, but also to serve as tools for users of a specific culture.

It is important to understand the difference between what is comprehensible to a culture and what is acceptable. Because social norms, values, and traditions vary greatly between cultures, what is acceptable in one culture can be objectionable in another. In addition, it has been argued that what is known in one culture may have little or no meaning in another. This was addressed by Russo and Boor (1993) who gave an example of a trash can from Thailand which looks different from a US trash can. They believed that the Thai user is likely to be confused by the US trash can image [15]. It is believed that culture affects a user's perception and understanding of interface elements.

2.3. Cognitive Style

Cognitive style is an influential factor in users' information seeking, it refers to how the learner process information and represent the individual's mode of thinking, remembering, perceiving, and problem solving [16]. Frias-Martinez, et al. (2008) listed a number of dimensions of cognitive styles; Holism/Serialism; Divergent/Convergent; Field Dependence/Independence; and Imager/Verbalizer, and characterized Field Dependence/Independence and Imager/Verbalizer are especially as they are related to information seeking. He argued that Dependence /Independence concerns with how users process and organize information whereas Imager/Verbalizer emphasizes how users perceive the presentation of information [17].

Technology based learning systems provide users with freedom of navigation that allows them to develop learning pathways. Much empirical evidence indicates that not all learners can benefit from these systems. In particular, some learners have problems dealing with non-linear learning. Research into individual differences suggests that a learner's cognitive style has considerable effect on his or her learning. Moreover, in a traditional learning environment, matching a user's cognitive style with content presentation has been shown to enhance performance and improve perception [11]. Simply, cognitive style is known as an important factor that influences learners' preferences. Three divisions of cognitive styles are discussed below.

2.3.1. Field-Dependent versus Field-Independent

Field dependence (FD) and field independence (FI) refers to an analytical or global approach to learning, and is probably the most well-known division of cognitive styles [18]. FI learners generally are analytical in their approach, whereas FD learners are more global in their perceptions. Many experimental studies have argued the impact of FD and FI on the learning process. Jonassen & Grabowski (1993) stated that Field Dependence/Independence is related to the degree to which a user's perception or of information is influenced by the environment [19].

With regard to navigation strategies, some studies suggest that FI users prefer navigational structures such as "index" and "find" to locate specific content [20]. Conversely, FD users tend to see a global picture [18], and prefer to use well-structured tools such as maps or main menus [21]. Additionally, some studies found that FI users relatively enjoy non-linear navigation while FD users seem to prefer a fixed path to navigate computer-based content. Table 1 shows FD and FI categories.

Table 1: FD and FI categories, Source from Chen (2002) [7].

Field dependent learners	Field independent learners
More likely to face difficulties in restructuring new information and forging links with prior knowledge	Able to reorganise information to provide a context for prior knowledge
Their personalities show a greater social orientation	They are influenced less by social reinforcement
Experience surroundings in a relatively global fashion, passively conforming to the influence of the prevailing field or context	Experience surroundings analytically, with objects experienced as being discrete from their backgrounds
Demonstrate fewer proportional reasoning skills	Demonstrate greater proportional reasoning skills
Prefer working in groups	Prefer working alone
Struggle with individual elements	Good with problems that require taking elements out of their whole context
Externally directed	Internally directed
Influenced by salient features	Individualistic
Accept ideas as presented	Accept ideas strengthened through analysis

2.3.2. Visualized versus Verbalized

There are many divisions of cognitive styles, among which Riding (1991) [22] Visualizer / Verbalizer particularly emphasizes the presentation of information. Since multimedia systems incorporate numerous ways to present information, such as text, graphics, sound, animation and video, multimedia content was found to significantly influence users' levels of understanding and enjoyment. The main differences between the two cognitive styles, Visualizers and Verbalizers, are described in [19] are shown in Table 2.

A Visualizer prefers to receive information via graphics, pictures, and images, whereas a Verbalizer prefers to process information in the form of words, either written or spoken. Visualizers prefer to process information by seeing, whereas Verbalizers prefer to process information by listening and talking.

Table 2: The differences between Visualizers and Verbalizers (adapted from Jonassen and Grabowski (1993) [19] and Riding & Rayner (1998) [23])

Visualizers	Verbalizers
Think concretely	Think abstractly
Have high imagery ability	Have low imagery ability
Like graphics	Like reading text or listening
Prefer to be shown how to do something	Prefer to read about how to do something
Are more subjective about what they are learning	Are more objective about what they are learning

2.3.3. Holist versus Serialist Strategy

In the Chen (2002) [7] study, two versions of a hypermedia learning system, the Breadth-first and the Depth-first, were designed with program control paths. In the Depth-first version, each topic was presented in detail before the next topic, which was presented in the same way (i.e., Serialist condition). The material was classified into seven depth levels. In contrast, the Breadth-first version provides a summary of all of the material prior to introducing detail (i.e., Holist condition), and included 12 categories in breadth.

Results showed that users whose cognitive styles were matched to the design of hypermedia learning systems that they preferred achieved higher posttest scores. Field Dependent learners performed better in the Breadth-first version than in the Depth-first version. On the other hand, Field Independent users performed best in the Depth-first version than in the Breadth-first version. The differences that characterize the holist-serialist dimension of style as approaches to learning are listed in Table (3).

Table 3: Characteristics of Holists-Serialists. Source, Jing (2005) [24]

Holist	Serialist
Top-down processor	Bottom-up processor
Global approach to learning	Local approach to learning
Simultaneous processing	Linear processing
Spans various levels at once	Works step by step
Interconnects theoretical and practical aspects	Aspects learned separately
Conceptually orientated	Detail orientated
Comprehension learning bias	Operational learning bias
Relates concepts to prior experience	Relates characteristics within concept
Broad description building	Narrow procedure building
Low discrimination skills	High discrimination skills

3. Methodology Design

In this research, we used quantitative data analysis obtained from a log file generated by using the Computer Based Learning (CBL) program and from a questionnaire. We define our independent values as males and females in addition to the total number of frames pages visited from map frame (non-linear structure) and total number of frames pages visited from index frames (linear structure). We should differentiate between linear and nonlinear approach since it is our main research focus. In a linear structure learners has no facility to jump to out-of-order slides, where with a non-linear structure, learners can access any point of the program, it is a presentation with hyperlinks, learners can navigate to other points in the presentation by simply linking to them.

The central theme of this research paper is to understand the influence of learning style on learners' use and preference of the CBL program which has two structures (linear and non-linear structure). This study tries to confirm the following hypotheses:

Hypothesis 1: Females are more likely use non-linear structure.

Hypothesis 2: Males are more likely use linear structure.

3.1. Participants

We conducted the experiment at the Higher Institute of Telecommunication and Navigation (HITN) in Kuwait. The total number of participants was 86 and their ages ranged between 18 and 26 years. Participants had different computing and internet skills and were classified in terms of gender. Males (N=43) and females (N=43).

3.2. Research Instruments

This research used two instruments, a log file from the CBL program and a questionnaire. The CBL program presents learning materials entitles "an introduction to PowerPoint". The program provides participants with, navigational structures, including a hierarchical map (non-linear structure) and an alphabetical index (linear structure) (Figure 1). In this approach, learners are given control to decide to choose their own learning paths and their favored navigation display.

When a participant clicked on any displayed link in the program, whither from the Map Frame or the Index Frame, a log file records records participant movement and registered visited pages, the clicks then saved in a log file.

A questionnaire was used to capture the users' subjective feelings and perceptions regarding the hypermedia learning environment. The questionnaire responses were made up of 5-point Likert scales which had the following possible responses: "strongly agree", "agree", "neutral", "disagree", and "strongly disagree". There are three questions in the questionnaire: a) "I like the fact that I have the ability to control the pace of instruction using Hierarchal Map", b) "I like the fact that I have the ability to control the pace of instruction using index" and c) "I like the fact that I can see the both frames of navigational structures, map and index frames". Questions a) and b) were used to understand the learners' perception of using map and index in displaying the instruction respectively, while question c) reflects learners' perception whether they like to see the frames of navigational structures, map and index frames, to be displayed.

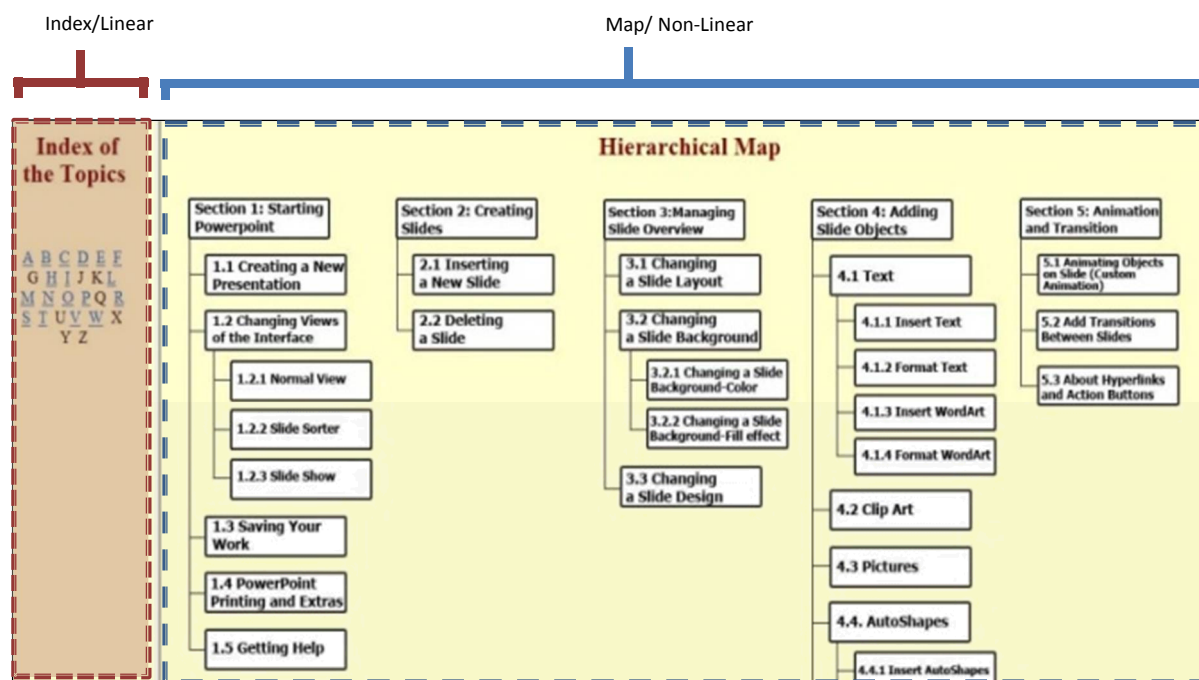


Figure 1: The main page of the CBL program.

3.3. Procedures

The experiment consisted of two phases. All participants were given an introduction to the use of the CBL programs. The students then were given a set of tasks to complete on PowerPoint while utilizing the CBL. In order to capture the behavior and perception of each user, a log file of our CBL program was used to log every hit the participant makes. They were then asked to spend 2 hours interacting with the CBL program using a task. In this way, participants were free to choose their preferred navigational structures, index frames and map frame. Their interactions with the CBL were stored in a log file. The log file recorded participant movement and registered visited pages. Finally, a questionnaire was handled to participants to collect data about learners' perception of using the CBL program.

3.4. Data Analysis

In our study, we used the independent-samples t-test. We defined our independent values as gender and the dependent variables as: a) total number of frames pages visited from map frame (map-pages), b) total number of frames pages visited from index frames (index -pages). T-test was used because it compares the means of two groups, in our case males vs. females.

The novelty of our study is to investigate the learning preferences of different learning styles in using linear/non-linear navigation. A significance level of $p < 0.05$ was adopted for the studies. More specifically, the frequencies

of using the non-linear/map and the linear/index between groups were analyzed.

4. Results and Discussion

4.1. Learning Style and Learners' Preferences

In our study, we investigated the learners' preferences in using the linear (index) and non-linear (map) navigational structures. We did this by comparing the number of pages visited by males and females (see Table 4). These pages are those from map and index. We found that there is no significant difference ($p > .05$) in preferences between males and females in using map pages. This means that Hypothesis 1 is rejected. However, females showed a preferences in using the map pages where their mean value = 13.60 which is more than males' mean values = 7.91.

On the other hand, when we tested the gender preferences in using index, we found that there is a significant difference ($p < .05$) between males and females in using index. We found that males preferred using index pages (mean = 12.26) more than females (mean = 3.16). This means that Hypothesis 2 is accepted.

Table 4: Frames pages visited from Map/index for females vs. males

Gender: M=Male, F=Female	Sig.	Mean	Std. Deviation
Total number of frames pages visited from Map	.121	13.60	9.284
Total number of frames pages visited from Index		7.91	6.003
Total number of frames pages visited from Map	.000	3.16	3.823
Total number of frames pages visited from Index		12.26	7.423

Since Field Independence (FI) users prefer navigational structures such as “index” and they prefer to use “find” to locate specific content [20]. Males can be identified as FI learners. Conversely, Field Dependence (FD) users tend to see a global picture [25], and prefer to use well-structured structures such as maps or main menus [10]. Thus, females are those who may identified as FD learners. However, investigation needs to be conducted to prove this.

As the main differences between the two cognitive styles, visualizers and verbalizers are described in Table 2 by Jonassen and Grabowski (1993) [19]. A visualizer prefers to receive information via graphics, pictures, whereas a verbalizer prefers processing information using words. Males can be identified as verbalizers because index frame provide learners the way of navigation when allocating key words for searching. Thus, females are those who may identified as visualizer learners where map frame provide the graphic presentation. However, this may also needs more investigation to be proved.

From Table 3, as previously discussed, we focused on the differences between holist and serialist learner. This table shows that the holist learners prefer the global approach to learning, simultaneous processing, spans various levels at once, conceptually orientated, and broad description building. Thus, females tend to have the holist style while using the non-linear structure. On the other hand, males tend to be serialist learners because they use the linear structure which provides local approach to learning, linear processing, works step by step, detail orientated and narrow procedure building which is provided in the index frame.

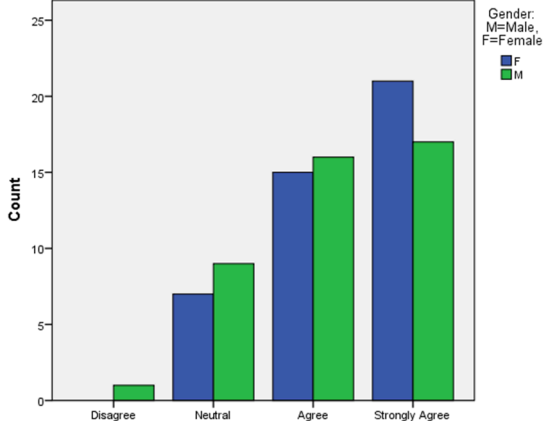
4.2. Learning Perception of CBL Program

Tables 5, 6, and 7 present results of questionnaire provided from learners. In Table 5, we found that the highest numbers of males (total of N=33) and females (total of N=36) had a positive perception in having the instruction provided by map where they mostly show their perception as “Agree” and “Strongly Agree”.

Table 5: I like the fact that I have the ability to control thepace of instruction using Hierarchal Map.

	Gender: M=Male, F=Female		Total
	F	M	
Disagree	0	1	1
Neutral	7	9	16
Agree	15	16	31
Strongly Agree	21	17	38
Total	43	43	86

Bar Chart

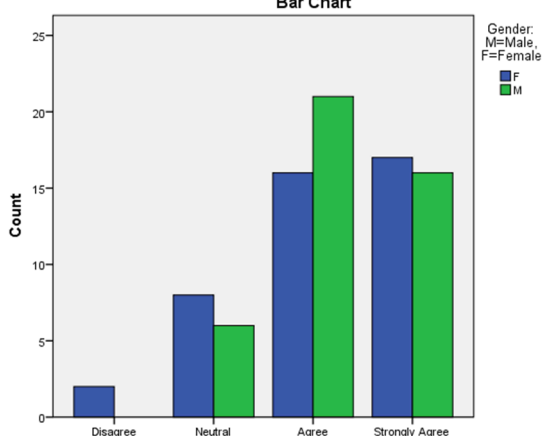


In Table 6, we also found that the highest numbers of males (total of N=37) and females (total of N=33) had a positive perception in having the instruction provided by index as they mostly show their perception as “Agree” and “Strongly Agree”.

Table 6: I like the fact that I have the ability to control the pace of instruction using index

	Gender: M=Male, F=Female		Total
	F	M	
Disagree	2	0	2
Neutral	8	6	14
Agree	16	21	37
Strongly Agree	17	16	33
Total	43	43	86

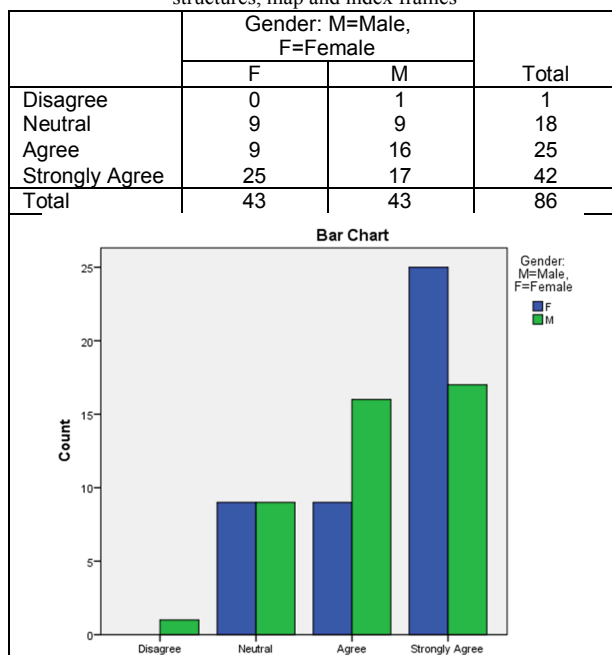
Bar Chart



In Table 7, the results of question “I like the fact that I can see the both frames of navigational structures, map and index frames” is provided. We found that females had the

highest number (N=25) of “Strongly Agree” perception. Furthermore, both males and females liked the fact of seeing both frames of navigational structures, map and index frames because most of their responses were shifted to “Agree” and “Strongly Agree”.

Table 7: I like the fact that I can see the both frames of navigational structures, map and index frames



To summarize the previous discussions, it is clear that both males and females liked the fact that they can see both of the navigational structures map and index in the CBL program.

5. Conclusion

This paper highlighted various factors which influence learning when using and designing technology based learning. These factors include individual differences on learners such as gender, culture, and cognitive style.

Data analysis was used to understand learners' needs and perceptions in using navigational structures. Such investigation was done to explore the relationships between learners' needs, learning styles, perceptions, and preferences using the CBL program in regard to their gender.

In this study, we conclude that female learners need to use non-linear structure, while male learners counterparts need to use linear structure. The results also shows that females are more visualized, field dependent and holist learners, while males are more verbalized, field independent and serialist learners. The results of the questionnaire helped to understand learners' perception that they prefer having both

navigational structures to be presented. This implies that a learner may use specific display accommodated in a CBL program although it may not be what they prefer. These findings emphasis that “*what learners like may not be what they need*” [26].

Understanding individual differences of learners and learner's characteristics will undoubtedly help designers to provide an effective technology based learning materials, in which users can acquire knowledge that will meet their individual needs, resulting in better perception and improved learning patterns. As a future work, further studies can be conducted utilizing data mining to provide a deep understanding of learners' needs and how this may affect their preferences.

The growing number of mobile applications in education adds more complexity to the design and development of educational interfaces with consideration to individual differences of learners. More research and more investigation will be an added value to this field of study for understanding learners and how this technology may affect learner's needs and preferences.

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