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Linear and Non-Linear Navigations of Learning Content

Effects on Engagement within Web-Based Instruction

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***Abstract*: This paper reports a study concerning linear and non-linear navigations in WBI. The effects of the two navigations on students' engagement aspects namely; control, focus, curiosity, and intrinsic interests were investigated. The study aimed to identify whether the linear and the non-linear navigations could be the factors that influence students' engagement while learning in WBI environment. An exploratory experimental study was conducted on seventy-two students from a university in Malaysia using a web-based system for learning Basic Computer Networks. The study suggested that the types of navigations had affected the control aspect, but not the focus, curiosity, and intrinsic interests. Students' engagement from the context of focus, intrinsic interests and curiosity was similar in both linear and non-linear. These findings are further discussed from cultural perspectives of Malaysian students.**

***Keywords*:** navigation, linear, non-linear, engagement, web-based instruction

I. Introduction

Navigation support in web-based instruction (WBI) is a crucial research area of human-computer interaction [1]. It emerges as a result of extensive WBI implementation for delivering various courses especially in higher learning institutions. One of WBI important aspects is a proper organisation of digital learning content that can stimulate learning effectively. It also requires an appropriate navigation support that can facilitate learning for students with different background. The issue is, how and what navigation support should be offered to students? In order to design an effective navigation support of WBI, developers should first understand students' navigation preferences or styles.

Navigation styles in WBI can be classified into two; linear and non-linear [2]. With linear navigation, students follow the predefined buttons (e.g., next and back) to navigate learning content. Although it creates a learning path that helps students to learn the content in a proper way, the linear navigation limits student's control over the content. As an alternative to this, the non-linear has been widely used in WBI. It gives students greater control over the content and allows them to access it according to their needs. However, some students do not always able to manage the high level of control offered by the non-linear, which may cause them to lost their learning paths [3]. Both linear and non-linear navigations have equal advantages and disadvantages; hence, this has inspired the authors to expand the existing studies by emphasising on the effects of the navigation preferences on student's motivational perspectives.

This paper reports the authors' study on linear and non-linear navigations of learning content in WBI from student's engagement perspectives. The paper is organised as follow. In section II, the authors explain the basic concepts of navigation in WBI, and some engagement aspects that related to them. It also includes the research questions and related studies by other researchers in the field. Section III describes an exploratory experimental study and the results are presented in Section IV. The authors discuss the findings and conclude them in Section V.

II. Navigation of Learning Content in WBI

WBI is increasingly important as a medium to support the traditional teaching approach in higher learning institutions. It can be proved by studies in 2010 that reported an increasing number in e-learning provisions within the UK universities [4] and enrolment of online courses within the US universities [5]. Not only in the UK and US, students from other countries around the world are highly depending on WBI for their learning, including Malaysia. In Malaysia, many working adults use WBI as a means to obtain higher academic qualifications for their career advancement [6]. WBI has also been widely used by full-time students in campuses to complement the traditional lecture. It has been included in Malaysian higher education system as its primary agenda [7]. This has shown that WBI is an important tool for learning, hence, research in this area could improve its functions towards supporting effective learning.

An interesting research area in WBI is concerning its navigation support. It is a basic component of any web-based application that gauges how effective it is, from human-computer interaction perspective. In simpler words, navigation affects web usability [8]. A good navigation allows users to access information quickly [9], and guides them to the required content by giving an appropriate path to reach the destination [10]. A good content navigation technique helps students to learn and obtain knowledge effectively [11]. In contrast, a poor navigation technique leads to disorientation [12] and cognitive load [13] that hinders effective learning.

Navigation in WBI comprises two categories: linear and non-linear [2]. In linear navigation, the process is controlled by the system [14]. Path to access the content has been predetermined either dynamically (following students' needs) or statically (fix path). Students have no control over the sequence or path of learning content. They simply press the provided buttons to move forward or backward. In non-linear, students have greater control over the content compared to the linear. Martin [14] defined non-linear as a type of navigation that allows students to freely navigate the content and follow their own path. No specific path is determined by the system, which resulted in greater flexibility to browse the content than the linear navigation.

Past studies in linear and non-linear navigation of WBI showed mix results. Connelly *et al.* [15] found that students make the least mistakes with linear navigation. Further, researchers like Gauss and Urbas [16] suggested that the linear navigation can reduce disorientation among students with low prior knowledge. However, a study by Baylor [17] had a contradict result with Gauss and Urbas. He found that linear navigation is more likely to cause disorientation to students than the non-linear. His study was about a searching task that required the students to locate five sentences from a passage rendered in nine web pages.

The other benefits of non-linear navigation include: (i) provides higher interactivity [18], (ii) easy to design, and (iii) attractive [19] compared to linear navigation. Al-Hajri *et al.* [20] emphasised that non-linear learning may not be suitable to all learners. They also argued that neither linear nor non-linear will improve students' performance because students are individually different. They suggested that; "*only the navigation approaches that accommodate students' differences will result in better performance".* This is true when we refer to Chen *et al.*'s [3] study. Their study suggested that prior knowledge should be considered when designing a navigation support for WBI. Some studies in the past had also supported that WBI navigation should be designed according to student's individual difference. Table 1 summarises the results of some empirical studies and the factors that influence navigation styles including field dependency, level of knowledge, gender, and system experience.

Table 1. Factors influencing the types of navigation in WBI

Factors	Linear	Non-linear
Field dependency [20]	Field dependency students prefer a linear content navigation	Field independency relatively enjoy non-linear content navigation
Level of knowledge [21]	Novice students learn better with linear navigation	Expert students learn better with non-linear navigation
Gender [1]	Female students prefer linear organisation of learning content	Male students prefer non-linear learning content organisation
System experience [1]	Students who are not familiar with a particular system prefer linear navigation	Students who familiar with a particular system prefer a non-linear navigation

A. The effects of navigation style on student's engagement

Motivation is an important component that influences the outcomes of a learning process [16]. Klein *et al.* [22] found that motivation-to-study has been positively correlated to course outcomes of web-based training. Simply put, students who have high motivation would achieve more in their course outcomes compared to students with low motivation. In the context of WBI, students have to learn how to motivate themselves to participate in the learning environment [23]. As motivation levels are different between students, WBI should offer students with conducive and effective learning environment. Navigation support is believed as a component of WBI that can increase student engagement, hence improving their motivation to learn. This has been supported by Sosnovsky *et al.*'s [24] study that suggested adaptive navigation support can motivate students to access content beyond the required one, which is a good practice for lifelong learning.

Students' engagement and disengagement correlates with their motivation to learn. Engagement in the context of this study refers to cognitive engagement; a subjective experience persons have when they interact with computer systems [25]. Some studies used the concept of optimal experience or flow [26, 27] to describe the cognitive engagement. In this study, engagement is investigated from four aspects of learning: (i) control, (ii) focus, (iii) curiosity, and (iv) intrinsic interests. The following paragraphs describe them generally from the context of learning.

Control refers to the condition in which students have power over the learning activities. In this situation, students have power to keep the interactions between them and the systems on track. In the context of WBI, control is a critical component that affects students' motivation, performance and attitudes towards learning [28]. In fact, several studies on learner control in WBI have revealed that giving students control over learning activities leads to an improved academic achievement [29-31].

Besides control, the learning process also requires an optimal level of focus so that a meaningful learning can be obtained. *Attention focus* refers to a situation in which student's mind is absorbed by WBI activities. That is, it actually measures student's level of concentration in the given tasks. Saad éand Bahli [32] defined this condition as cognitive absorption, which plays an important role in generating more positive attitudes towards learning and greater exploratory use of the system.

Webster *et al.* [33] confirmed a positive relationship between attention focus and curiosity. They defined *curiosity* as the situation in which a student is enthusiastic to learn more about the domain knowledge. It is important to note that the state of curiosity is always inconsistent. Small and Arnone [34] suggested that sufficient and relevant information can increase curiosity. They claimed that motivation could be increased when student is provided with the information that is required for learning; thus, encouraging the student to explore more about the topic. Consequently, in the context of WBI, insufficient information or knowledge that a student anticipates during a learning process may lead to a significant decrease or even extinction of curiosity.

The last aspect of engagement is *intrinsic interests,* which can be defined as a situation in which a student feels enjoyment with the learning activities. This can be further

described by the reasons that motivate the student to learn. A student with intrinsic interests engages in WBI for the sake of the learning itself without apparent force [35]. Researchers in the area of WBI acknowledge that a proper design of computer systems can help in stimulating intrinsic interests.

Control, focus, curiosity, and intrinsic interest are studied with regard to navigation support. It aims to understand the effects of navigation styles (i.e., linear, and non-linear) on the engagement aspects among adult students in Malaysia. As many Malaysian students use WBI in their courses, the authors are interested to identify whether specific types of navigation in WBI will provide them with appropriate navigation support. To be specific, the study attempts to answer "*what is the effect of linear and non-linear navigations of learning content on student's control, focus, curiosity and intrinsic interests?*".

III. Experimental Study

An experimental study was carried out to study the effects of linear and non-linear navigations on the four aspects of engagement (i.e., control, focus, curiosity, and intrinsic interests). This section explains the methods for conducting the study and its results.

A. Participants

The study recruited students of Universiti Utara Malaysia between May to December 2010 through advertisement in emails and the university's learning management system (LMS). A total of 72 students comprised 33 males and 39 females were recruited. Their mean age was 24.03 ranging from 18 to 45 years with majority of the students were aged between 21 to 25 years (52 students). Most of them were undergraduate students with only 7 from them were from postgraduate programmes. The students who participated in this study took various courses including information technology (30 students); accounting (5 students); business, multimedia, development, agribusiness, tourism, and technology management (3 students respectively); economics, business mathematics, international business, and media technology (2 students respectively); and, human resource, psychology, Islamic business administration, public management, operation management, marketing, international affairs, entrepreneurship, communication, and education (1 student respectively).

B. Materials

Materials for the study consisted of two web-based systems and a questionnaire. The two systems were designed and developed following a course syllabus for the Information Technology (IT) fundamental course offered by the School of Computing, Universiti Utara Malaysia. The original system was known as IT-Tutor with linear navigation. However, for the purpose of this study, the same system has been modified to include the non-linear navigation. Both systems covered a module named "Basic Computer Networks". Figure 1 shows the contents of the module. The same instruments were also use in other studies such as reported in [36-44].

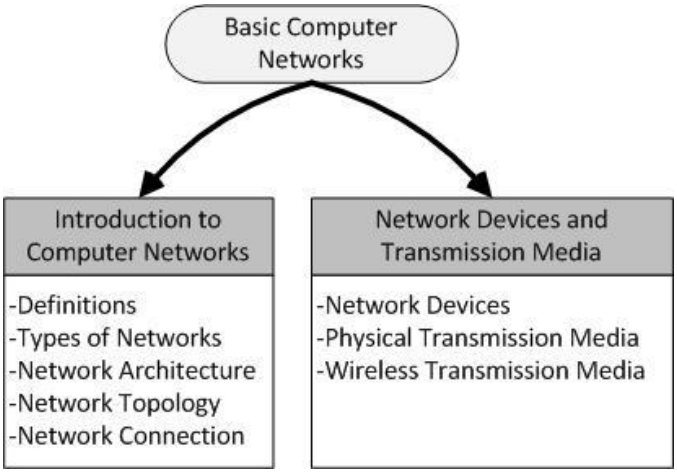

Figure 1. The contents of the module

The web-based systems organised learning content in multimedia formats (i.e., text and images). The systems consist of three main components: quizzes, feedbacks, and explanations. The quizzes are used to evaluate students' prior and current knowledge about the module. The feedbacks notify the students about the answers of the quiz and the associated explanations that they need to know. The explanations are the associated knowledge that gives details of the quizzes. This is the component where linear and non-linear navigations have been implemented. Figure 2 illustrates the learning process that students need to follow with linear (Figure 2a) or non-linear (Figure 2b) navigation.

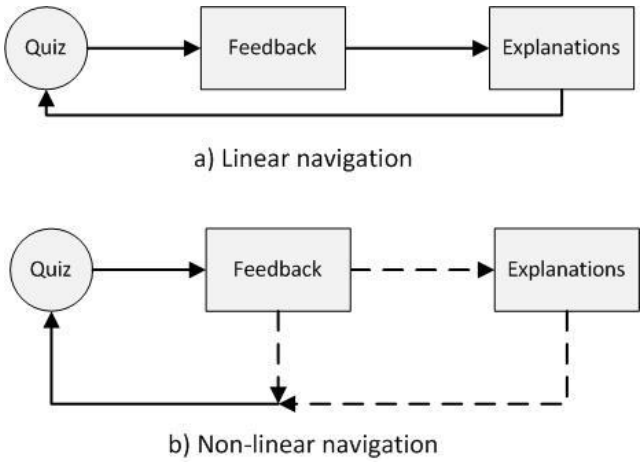

Figure 2. Linear and Non-linear navigation of the web-based systems

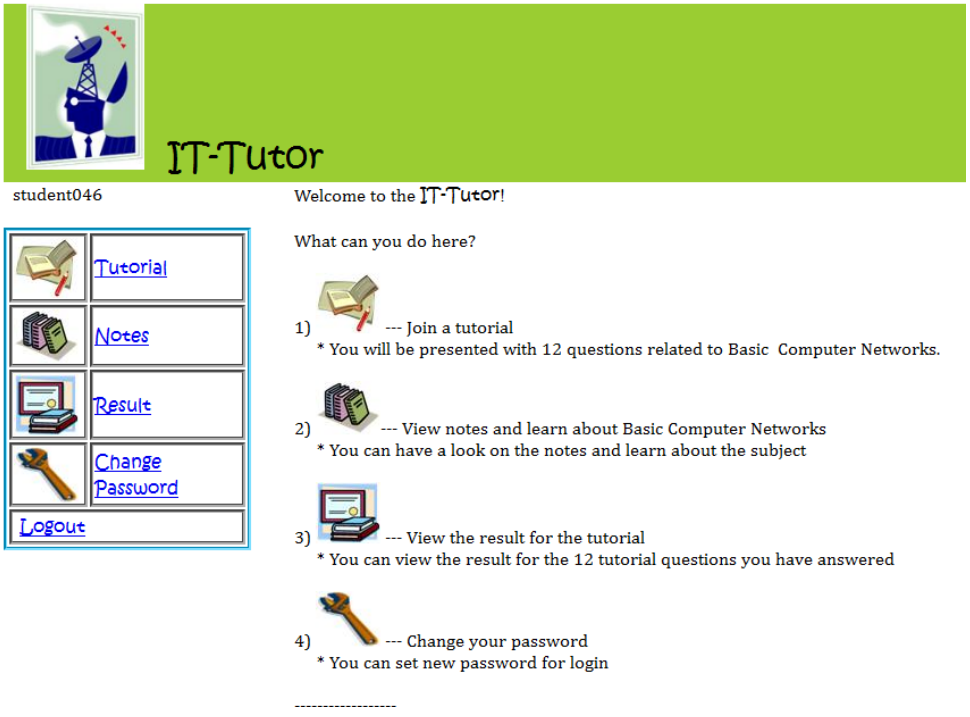

Figure 3. The main interface of the web-based learning system

Both linear and non-linear web-based systems pose a quiz comprises four questions in every stage of three. When students answer the quiz, both systems analyse the answer and give feedbacks to students. The feedbacks inform the students whether their answers are correct and if not, they will suggest the content or explanation that the students need to read/learn. After the students access the explanations (either in linear or non-linear ways), they will be forwarded to the next stage of the tutorial which is a new set of quiz. This process will be repeated three times in both systems.

Back to the presentation and organisation of the explanations, the linear navigation automatically presents the explanations to the students following the pre-identified contents (they have been generated according to the answers of the quizzes). On the other hand, the non-linear navigation allows the students to navigate the contents according to their own navigation paths. As shown in Figure 2a, students will be automatically presented with the explanations after they receive the feedbacks. They can move from one content to another using the given next/back buttons. When they have gone through the explanations, they will move to the next stage of the quiz. Unlike the linear, the non-linear allows the students either to browse the learning notes independently or simply move to next stage of the quiz. This is represented by the dotted line in Figure 2b. Refer to Figure 3 for an example of the main system's user interface.

Some screenshots of the systems have been captured and presented here. Figure 4 and 5 shows a screenshot for the quiz section and feedback respectively. The examples of linear and non-linear navigations are shown in Figure 6 and Figure 7 respectively.

The study used a questionnaire as an instrument to measure the effects of linear and non-linear navigations. This questionnaire was adapted from Webster *et al.* [33]. It has also been validated by other recent studies [45-47]. The questionnaire comprised twelve items that specifically asked students about their experiences interacting with computer systems as shown in Table 2. A five-point Likert scale (1 for strongly disagree and 5 for strongly agree) was used in the questionnaire.

Table 2. The questionnaire for the experimental study (as adapted from Webster *et al.* [33])

Aspects of Engagement	**Questions**
Control	C1- When using IT-Tutor, I felt in control over everything
	C2- I felt that I had no control over my learning process with IT-Tutor
	C3- IT-Tutor allowed me to control the whole learning process
Focus	F1- When using IT-Tutor, I thought about other things
	F2- When using IT-Tutor, I was aware of distractions
	F3- When using IT-Tutor, I was totally absorbed in what I was doing
Curiosity	CU1- Using IT-Tutor excited my curiosity
	CU2- Interacting with IT-Tutor made me curious
	CU3- Using IT-Tutor aroused my imagination
Intrinsic Interests	I1- Using IT-Tutor bored me
	I2- Using IT-Tutor was intrinsically interesting
	I3- IT-Tutor was fun for me to use

Figure 4. An example of screenshot for the quiz section

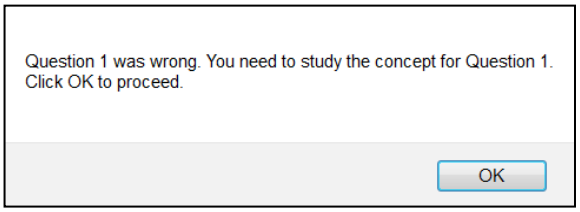

Figure 5. An example of screenshot for the feedback

Figure 6. An example of screenshot for the explanations in linear navigation

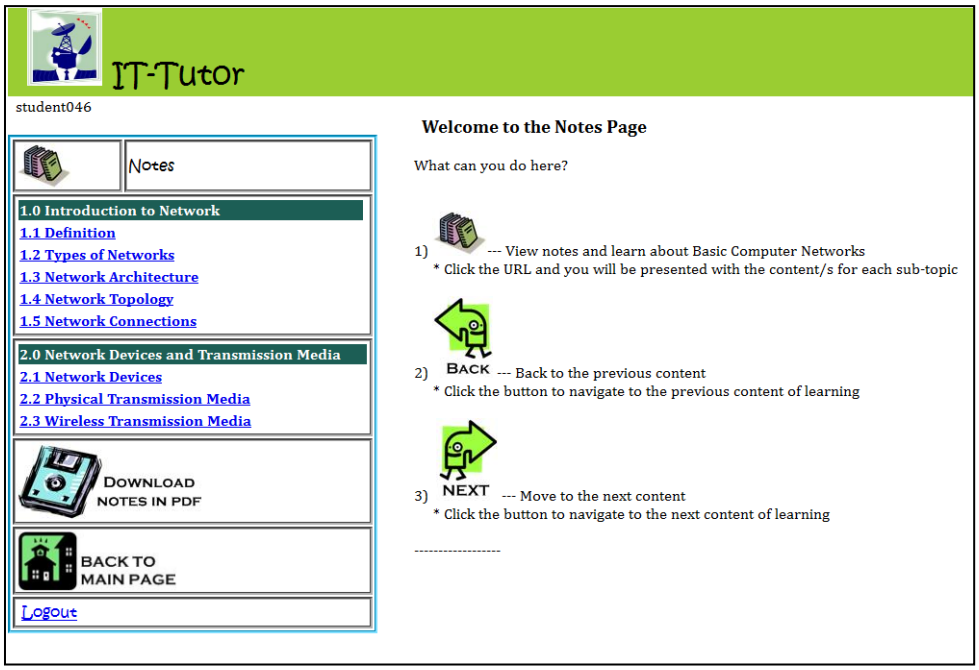

Figure 7. An example of screenshot for the explanations in non-linear navigation

C. Procedure

The experimental study was conducted in online and unsupervised mode. The students who agreed to participate were given a URL (a web link) to access the materials. They were allowed to perform the tasks at their own convenience. Once they accessed the web link, an information sheet about the study was presented. Then they were asked about their consent-to-participate in the study by accepting the given terms and conditions. After that, the students were randomly assigned to either linear or non-linear system using a binary random number generator. Then they were required to interact with the systems (answering the quiz, and learning the content). When they completed the task, the questionnaire was given to them. Figure 8 shows the tasks that the students had to complete. Their interactions were logged and if they had been inactive (no interactions such as moving the mouse, and scrolling down the vertical bar) for more than five minutes, they would be logged off from the systems. This was done to protect the reliability of the data in online and unsupervised experimental study.

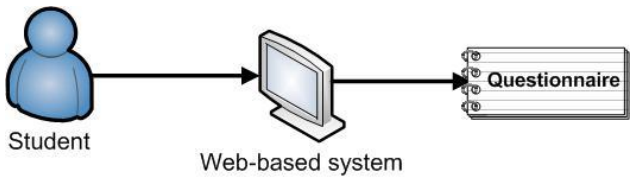

Figure 8. The tasks that students had to complete

IV. Results

The data of this study were analysed using SPSS (version 19). A reliability test was conducted on the twelve items of the questionnaire. The Cronbach's alpha coefficient was 0.774 suggesting that the data had relatively high internal consistency (refer to Figure 9 for the statistics value). A normality test following Kolmogorov-Smirnov (K-S) was also conducted on the data, and the result suggests that they were non-normal with $p<0.002$ for all items. This may due to small sample size of the study. As the data were not-normally distributed, non-parametric tests were applied in the analysis

Reliability Statistics

Cronbach's Alpha	N of Items
.774	12

Figure 9. The screenshot for the reliability test

A. Control

In terms of the control aspect, the students with the non-linear positively agreed that the navigation gave them control over the learning content. Specifically in question C2 that is "*I felt that I had no control over my learning process with IT-Tutor*", the students with the non-linear WBI rated significantly lower (2.51) than the linear students (3.15). The difference was statistically proven by the Mann-Whitney U test ($Z=-2.092$, $p=0.036$, $p<0.05$). This suggests that the linear navigation gave the students higher level of control over the learning content than the linear in the given WBI.

Table 3. The means (and standard deviations) for the linear and non-linear for the control aspect

Aspect of Engagement	Questions	Linear (n=33)	Non-linear (n=39)
Control	C1- When using IT-Tutor, I felt in control over everything	3.52 (1.093)	3.95 (0.793)
	C2- I felt that I had no control over my learning process with IT-Tutor	3.15 (1.176)	2.51 (1.374)
	C3- IT-Tutor allowed me to control the whole learning process	3.45 (1.034)	3.77 (0.986)

B) Focus

Table 4 shows the mean scores for question F1, F2, and F3 that represent the focus aspect. In question F1, the students with the linear WBI (3.45) reported that they thought about other things more than the non-linear (3.10). In terms of distractions (F2), both groups had approximately a similar score (3.3). When the students were asked whether they were absorbed in the learning activities; the non-linear students gave higher scores (3.67) than the linear students (3.48). To evaluate the differences between both groups, the Mann-Whitney U tests suggested that they were not statistically significant. Hence, this study proposed that the students in the linear and non-linear groups had similar level of focus towards the learning content.

Table 4. The means (and standard deviations) for the linear and non-linear for focus aspect

Aspect of Engagement	Questions	Linear (n=33)	Non-linear (n=39)
Focus	F1- When using IT-Tutor, I thought about other things	3.45 (1.227)	3.10 (1.252)
	F2- When using IT-Tutor, I was aware of distractions	3.30 (0.984)	3.31 (1.080)
	F3- When using IT-Tutor, I was totally absorbed in what I was doing	3.48 (0.939)	3.67 (1.084)

B. Curiosity

The mean scores for the curiosity aspect (CU1, CU2, and CU3) are presented in Table 5. The students in the non-linear group had higher mean scores than the linear for question CU1 and CU2. However, CU3 contradicted the first two questions. A series of Mann-Whitney U tests did not suggest any significant differences on these data. It can be said that the levels of curiosity were similar between students with the linear and the non-linear navigations.

Table 5. The means (and standard deviations) for the linear and non-linear for the curiosity aspect

Aspect of Engagement	Questions	Linear (n=33)	Non-linear (n=39)
Curiosity	CU1- Using IT-Tutor excited my curiosity	4.00 (0.707)	4.05 (1.075)
	CU2- Interacting with IT-Tutor made me curious	3.76 (0.902)	3.97 (1.063)
	CU3- Using IT-Tutor aroused my imagination	3.73 (0.944)	3.69 (1.004)

D. Intrinsic Interests

Information in Table 6 shows the mean scores for the three items of the intrinsic interest aspect (I1, I2, and I3). When the students were asked whether the learning made them bored, the non-linear had higher agreement then the linear students. When they were asked whether the systems were fun to use and intrinsically motivating, the linear students had higher agreement than the non-linear. However, the Mann-Whitney U tests suggested that the difference between the groups were not statistically significant.

Table 6. The means (and standard deviations) for the linear and non-linear for the intrinsic interests aspect

Aspect of Engagement	Questions	Linear (n=33)	Non-linear (n=39)
Intrinsic Interests	I1- Using IT-Tutor bored me	2.52 (1.252)	2.54 (1.165)
	I2- Using IT-Tutor was intrinsically interesting	3.82 (0.846)	3.62 (1.016)
	I3-IT-Tutor was fun for me to use	3.82 (0.769)	3.79 (1.128)

V. Discussion and Conclusion

In this study, the effects of linear and non-linear navigations of WBI were studied from four cognitive engagement perspectives namely; control, focus, curiosity, and intrinsic interests. As explained earlier in Section II, the past studies suggested that students need different types of navigation to achieve affective learning. This is due to some factors such as prior knowledge, experience, and gender that make them individually different. Further, researchers suggested that appropriate navigations should be designed to accommodate this difference especially in WBI environment, so that effective learning can be obtained. Based on the current state of research concerning WBI navigation, this study explored the effects of navigations on students' engagement. Specifically, it aimed to identify whether specific types of navigation could influence students' engagement while learning in WBI environment.

There are two important findings of this study. Firstly, it suggests that the linear and non-linear navigations had different effects on the students from the aspect of control. Specifically, the students with the non-linear navigation reported higher level of control than the linear students during interaction with the WBI. Secondly, the students' level of focus, curiosity and intrinsic interests were not affected by the navigation types, in which they had similar level of the three aspects respectively.

The first finding confirms the results of past studies [16, 48, 49] that suggesting non-linear navigation offered greater control over the web-based contents. However, the authors would like to emphasise that the non-linear navigation is not necessarily increase students' engagement in learning, although it offers greater control over the learning content. As this research did not have the data to show the relationship between control level and engagement, further research is required to improve these findings. Different methods (other than experimental study with self-report) can be used to investigate whether greater level of control can improve students' engagement to learn in WBI environment.

Another point concerning the non-linear navigation is the fact that it may cause disorientation, particularly when students have limited prior knowledge about the domain of learning [16]. To address the issue of disorientation in the non-linear, the authors support Brusilovsky's [50, 51] works on adaptive navigation that aims to improve this issue. He defined adaptive navigation as a type of non-sequential navigation that assists students to achieve effective knowledge acquisition process. In other words, adaptive navigation gives flexibility to students to navigate the content of WBI in their preferred ways either linear, non-linear, or both; and at the same time they can obtain the intended objectives of learning effectively [52]. Adaptive navigation is important to support users' needs, and to avoid usability problems [53].

The second finding of this research recommends that the aspects of focus, curiosity, and intrinsic interests were similar between students who used the linear and non-linear navigations. In other words, the result suggests that the types of navigations did not differentiate the students' focus, curiosity and intrinsic interests in the given WBI learning. However, this does not suggest that the navigation types did not affect their engagement in learning. It should be followed up with more extensive studies that focus on the relationships of navigation types and students' engagement in WBI environment.

The findings of this study should also be used with considerable caution due to cultural differences. Further, educational policy and practices in Malaysia are different with other countries which can cause diversity in learning, and differentiates them from students of other countries. This including learning in WBI environment. For example Lee *et al.* [54] studied the effects of culture and cognitive styles in hypermedia learning among Malaysian and Australian students of higher learning institutions. They found that Malaysian students prefer higher navigation supports than Australian when learning in hypermedia environment. This can be associated with educational practices in the primary and secondary levels of Malaysian education system where teachers always provide full guidance in classroom learning. The same practices are expected by the students to be available in other learning settings including WBI. Perhaps understanding the cultural effects of the linear and non-linear navigations in WBI could be another research opportunity.

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