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Progressive assessment of student engagement with web-based guided learning

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Abstract

Purpose – The purpose of this research is to investigate student engagement in guided web-based learning systems. It looks into students' engagement and their behavioral patterns in two types of guided learning systems (i.e. a fully- and a partially-guided). The research also aims to demonstrate how the engagement evolves from the beginning towards the end of the interactions; which enables analysis to be performed on the quality of engagement.

Design/methodology/approach – An experimental study was conducted on 41 students from a public university in Malaysia using two web-based systems as the main learning tools. The students' engagement data were captured three times during the interactions and once at the end of the experimental study using student self-report.

Findings – The main outcome of this study suggests that student engagement was changing over time either in positive or negative patterns. The directions of change in both types of guided learning were mainly influenced by the students' background of knowledge.

Practical implications – This study demonstrates that student engagement is dynamic. Therefore, progressive assessment is a practical approach to obtain the engagement data which can be used to regulate and improve student engagement in web-based systems. As a result, an adaptive and intelligent web-based learning environment can be created.

Originality/value – This research proposes a new approach to improve students' engagement in web-based instruction, that is, through a progressive assessment of their current experience.

Keywords Web-based, Guided learning, Engagement, Progressive, Behavioral patterns, Learning, Malaysia

Paper type Research paper

1. Introduction

Recent internet technology including the Web 2.0 enables the opportunity to deliver interactive and motivating learning activities online. It gives flexibility to instructional designers to use multimedia data such as audio, video, pictures, and animations that help students comprehend complex knowledge easier, and facilitates them to achieve meaningful learning (Mayer, 2005). Due to the benefits that the technology could offer to students, many higher learning institutions shift their strategy from the traditional lecture to online and distance learning systems. It is now a common scenario that students enroll in online courses and learn independently, without the need to attend lectures.

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Despite the growing usage and popularity of online learning systems, research shows that the attrition rates are higher in the online courses compared to the face-to-face mode (Angelino *et al.*, 2007). An exploratory study by Patterson and McFadden (2009) suggested that students were more likely to withdraw from the online courses than the face-to-face lecture. However, they also agreed that no specific theory can sufficiently explain the attrition issue as proposed by many prior researchers. Hence, they suggested a closer examination of the factors through a qualitative study which may help to identify the reasons of student attrition in online courses.

The reasons that lead to student attrition in online courses are vary and may be influenced by various factors such as the degree programs and delivery formats (Patterson and McFadden, 2009). A more practical approach to address this issue can be seen from the perspective of an online learning system itself. What we can see, the computer systems can be programmed in such a way that they will be more responsive and intelligent to motivate students to learn. Therefore, there is a need to improve the design of current online learning systems to naturally engage students with the given learning activities and perhaps regulate their level of engagement whenever necessary. This has been the main theme of discussion in this paper.

To discuss this topic in detail, the paper is divided into three sections. Section 2 describes literature related to engagement in online learning and elaborates two types of web-based guided systems used in the context of this research. Next, the empirical study and its findings are further discussed in Section 3. In Section 4, the author discusses the findings with regard to adaptive learning, and it is followed by a conclusion.

2. Engagement and guided learning

2.1 Engagement with learning

Engagement with learning has a broad definition and may be used differently. It may encompass various aspects including student engagement with school systems, or the level of focus attention that a student gives to answer a problem in a particular topic of learning. Specifically in the context of this paper, it comprises engagement with problems, a domain of knowledge, communities or small groups as outlined by Stahl (2005).

Engagement has also been associated with subjective experience that a person may undergo during an interaction with online learning (O'Brien and Toms, 2008). Often, this has been explained with regard to flow theory by Csikszentmihalyi (1975, 1990, 1997). In general, the theory describes how cognitive engagement happens when a person involves in an activity such as working, doing sports or other leisure activities.

The theory suggests that happiness is the ultimate outcome when a person performs an activity. It is an important element of human psychological well-being and can be characterized by features like positive emotions, clear goals and effective mental processes. These features will drive a person to achieve a mental state that Csikszentmihalyi defined as flow. When flow is achieved, a person will give maximum attention to the activity, be mentally absorbed, and concentrate on it. This is how engagement is defined in flow theory.

Level of engagement may differ within individuals, although they are given with a same activity. Macey and Schneider (2008) described it as variable, and can be characterized as either a behavior or a state. Level of engagement may also change (positive and negative ways) during an interaction. This can be further explained by a model known as model of engagement (ME) that has been proposed by O'Brien and

Toms (2008) to evaluate engagement with technology. The model suggested that engagement may have four stages:

(1) point of engagement;
(2) engagement;
(3) disengagement; and
(4) reengagement.

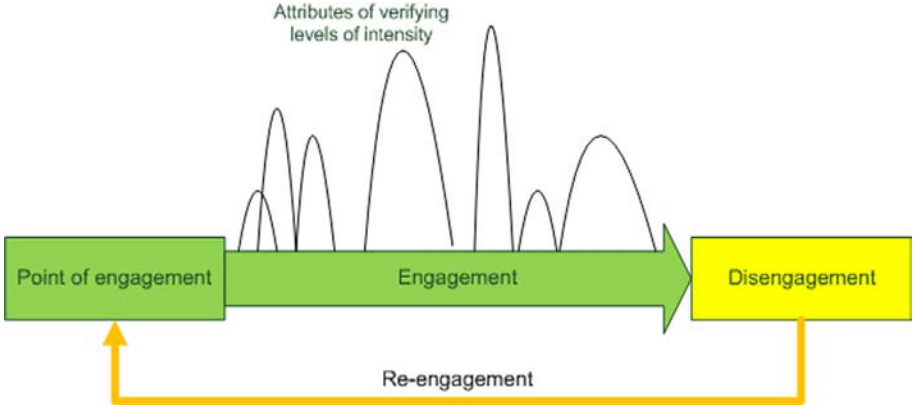
The point of engagement is initiated by intrinsic or extrinsic factors including motivation and external attractions. Engagement is sustained when attention and interest are maintained. However, disengagement may occur when there are significant distractions. Reengagement may substitute disengagement when distractions are not significant. Figure 1 shows the four phases in ME.

2.2 Guided web-based learning

Learning can be considered as a common activity that students perform frequently within the context of higher education. Many higher learning institutions offer students with an online learning mode; an alternative to face-to-face meeting that works flexibly for students in distance learning programs. Generally, online learning is a web-based learning (WBL) system that can be accessed through the internet and web browsers. It encourages students to learn independently at their convenient time and place.

Recent WBL and instructional design research suggests the use of personalized and adaptive systems that can help students to achieve meaningful learning. There are many ways for implementing adaptive learning systems (ALSs). One of them is through proper navigation; that is an important feature of usable web-based systems (Palmer, 2002). Researchers have started studying adaptive navigation in web-based systems since early of this century. Generally, adaptive navigation support assists users to identify paths in web-based systems that match users' characteristics and needs such as goals, knowledge and preferences (Brusilovsky, 2003).

Navigation support is one of e-learning usability components (Zaharias and Poylymenakou, 2009) and it plays important roles in shaping students'



Source: O'Brien and Toms (2008)

Figure 1.
Model of engagement

learning performance. Past studies have reported that poor navigation design leads to disorientation and increases cognitive load (Paulo Kushnir and Berry, 2010). This will subsequently hinder effective learning. Realizing the importance of navigation support in WBL environment; this research looks further into this aspect, particularly from the context of guided instruction.

A WBL system can be programmed in terms of its navigation techniques to give users guided experience. However, the guided instruction is not always suitable for everyone. A study by Chen *et al.* (2006b) suggested that students require different navigation support in WBL depending on their prior knowledge in particular domains of learning. In order to promote effective learning in web-based environment, novice students should be given with linear navigation, while expert students be given non-linear access. In this paper, both linear and non-linear access in WBL is regarded as guided learning. The fully-guided WBL offers students with linear navigation while the partially-guided allows students to perform non-linear access.

The fully-guided WBL is also known as content sequencing (Iglesias *et al.*, 2004; Chi, 2009) or curriculum sequencing (Stern and Woolf, 1998; Baldoni *et al.*, 2002; Darbhamulla and Lawhead, 2004; Pena *et al.*, 2004; Chen *et al.*, 2006a). The learning environment provides an optimal learning pathway to a student that is identified by investigating the student's background of knowledge, preferences, and learning goals (Chen *et al.*, 2006b). In order to have a personalized learning path, the systems usually employ quizzes or short questionnaire to obtain information about the student. Then, a sequence of learning path is generated dynamically according to the information and presented to the students following the identified sequence. Figure 2 shows the process.

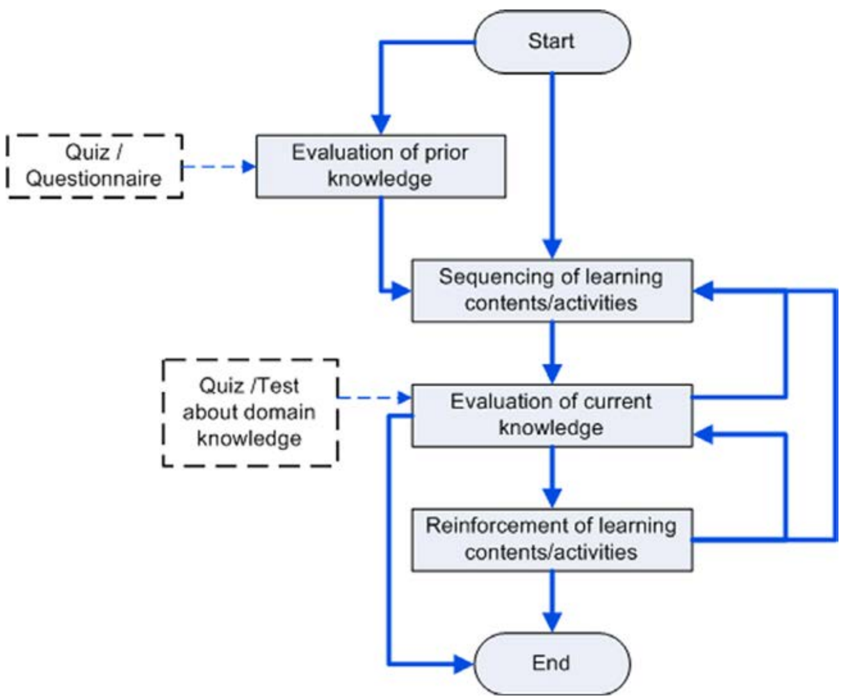


Figure 2.
A generic process of fully-guided WBL

The partially-guided learning is simple in terms of its practice. It is sometimes called as a recommendation system (Tang and McCalla, 2005; Zhu *et al.*, 2008; Klašnja-Milićević *et al.*, 2011). The recommendation system has some intelligent features that evaluate the student's learning parameters. Unlike the fully-guided learning, the partially-guided learning simply proposes the learning pathway to student and allows the student to navigate the suggested learning path in his or her own way.

From the context of independent and online learning, guidance is an important mechanism that helps student engagement (Baker *et al.*, 2010). However, the extent to which guidance should be given is unclear. Sweller *et al.* (2007) encourage studies that determine the amount and type of guidance required by different learners. This is important for the development of an effective learning environment especially from the context of students' cognitive and psychological well-being.

The results of past studies in educational psychology emphasizes that direct guidance should be given to students during learning process (Kirschner *et al.*, 2006) to avoid misconception and frustration due to insufficient information required during knowledge acquisition process. However, the level of guidance should be reduced when the level of expertise has improved (Kalyuga and Renkl, 2010). This situation can be explained by the expertise-reversal effect (Kalyuga *et al.*, 2003), in which instructional strategies that suitable for the novice are not necessarily effective for experienced students.

The effects of navigation on students' performance in learning, especially through retention and transfer tests have been studied by many researchers in the past. The results of their studies have shown significant improvements in terms of the design of current WBL systems. Hence, the author is interested to extend the study on the effect of web-based guided instruction from psychological and cognitive aspects. Particularly, students' engagement in using the guided WBL systems is the concern of this paper.

As WBL is used by students with different background of knowledge, how students engage in a particular learning session with guided WBL is an important topic. This can ensure that the guided WBL is truly adaptive and it motivates students to learn independently. Specifically, the research aims to answer a main research question that is "How engagement evolves in guided WBL?"

2.3 Adaptive learning systems

The internet technology shows a trend where developers and application providers are focusing on delivering personalized applications to their users. Web systems have been developed with intelligent features that can store user profiles and address the users individually. Social network sites and search engines use personalized information to render advertisement to their users.

The personalized web systems have attracted researchers to study this area further. This can be proven by the establishment of research labs, conferences, and professional special interest groups related to this area. For example, the Personalized Adaptive Web Systems (PAWS) lab was established in 2005 at the University of Pittsburgh to carry out studies related to adaptive web technology. Specialized conferences such as ADAPTIVE (www.iaria.org) and SASO (www.saso-conference.org/) are also conducted in annual basis to allow researchers in this field to disseminate their current research and development in adaptive web technology.

Adaptive learning has emerged as an important branch of research in adaptive web technology. The main objective of research in this area is to improve traditional e-learning systems from a static mode to a more flexible and engaging learning environment. ALSs gather information on students' profile and their interactions with the systems, develop an individual student model, and employ the model to identify the appropriate learning materials and presentation styles for the students (Brusilovsky *et al.*, 2004). Research in ALS is important as many past studies on learning and instruction found that students are individually different and they should be treated on individual basis to ensure they obtain effective learning.

Various ALSs for studying various subjects in different education levels have been developed within this decade. Robert *et al.* (2009) studied four ALSs that are cWADEIn, QuizGuide, NavEx, and Knowledge Sea II. These systems were chosen because they were available and accessible online. The researchers particularly studied the adaptation methods that the four systems had implemented. Despite the student model, adaptation models or techniques are one of ALS important components.

There are various adaptation models and techniques in the literature. Franzoni *et al.* (2008) studied the adaptation models that were used in seven ALSs. Their analysis showed that the systems analyzed students' learning styles and performed different techniques to adapt to them. In general, an adaptation model characterizes the adaptation behaviors using a set of rules. It identifies how student's actions can be transformed into a student model that later will be used to organize and sequence appropriate contents and presentation. Hendrix *et al.* (2008) defined two types of rules used in adaptation models that are generic (rules that can be applied in any domain of learning), and specific (rules that can only be implemented in specific concepts or domain of knowledge). An adaptation model usually consists of both generic and specific rules.

3. Method

The study aims to understand engagement in two types of guided WBL (i.e. a fully- and a partially-guided). An experimental study was conducted to understand and evaluate how students engaged with guided learning environments. The study analyzed two aspects of engagement. First, it measures how engagement evolved from the beginning towards the end of a guided WBL session. It was conducted by breaking a learning session into three stages and performed a separate evaluation at the end of each stage. Second, it measures the overall engagement at the end of the session. Both evaluations were performed through students' self-report.

3.1 Design and measures

A one-way between-subject design was employed in the study. The independent variable was the types of guided WBL systems (i.e. the fully- and the partially-guided). Two dependent variables were analyzed; student engagement (i.e. Stages 1-3), and the overall engagement.

3.2 Participants

A group of 41 students (i.e. 19 males and 22 females) from a university in Malaysia participated in the study on a voluntary basis. They were recruited through e-mails and advertisement in the university's learning management system (LMS) for some courses offered by the university. This experimental study was conducted in 2010 (i.e. from August to October).

3.3 Materials

The materials for the study comprised of three items; a pair of WBL tools, a short questionnaire and an extended questionnaire.

The first material was a WBL system for learning basic computer networks; a module in information technology (IT) fundamental course (Katuk and Ryu, 2010; Katuk and Ryu, 2011). The course comprised two chapters namely introduction to computer networks, and network devices and transmission media. The lessons in the first chapter were definitions of networks, types of networks, network architecture, network topology, and network connection. The topics in the second chapter were network devices, physical transmission media and wireless transmission media.

To ensure that the tool is easy to use, a usability evaluation was conducted. The tool was assessed by three web usability experts and two computer network instructors. They performed heuristic and formal evaluations on the tool. The results confirmed that the tool was usable and suitable to be used as an online learning system.

It runs on.NET platform and is accessible through the internet using any web browsers. Figure 3 shows the main interface of the system. The complete description and documentation of the system can be obtained from Katuk (2012).

The tools were available in a fully- and partially-guided system, respectively. The fully-guided WBL organizes learning materials dynamically based on the student's prior knowledge and the system presents the contents to the student automatically. In contrast, the partially-guided WBL system suggests the learning path of the learning content to the student. Then, the student is expected to browse the learning materials from the "notes page" independently. The guided WBL systems use printed text and

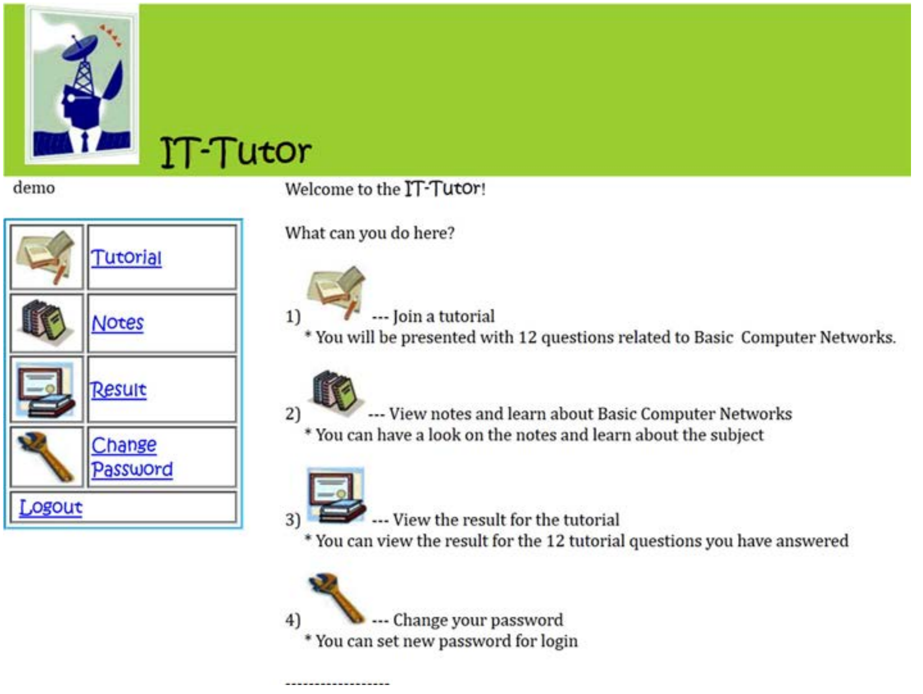


Figure 3.
The main interface of the guided WBL

images for presenting the learning contents to students. Table I shows the features for both fully- and partially-guided WBL.

In order to examine student prior and current knowledge, the tool employed a quiz containing 12 questions. The questions were ordered in a sequence that mapped with the contents of the modules. Students were required to answer the questions so that their knowledge can be assessed. The students' answers will be analyzed to identify the contents that must be presented to them. The tool will give them feedback on their answers and suggest what the students must do in the next step. Depending on the types of tool (either fully- or partially-guided), it will organize the learning path appropriately.

The extended questionnaire as shown in Table II was adapted from Park *et al.* (2010). The questionnaire contained twelve items in four dimensions of the engagement namely control, attention focus, curiosity, and intrinsic interests. Control refers to the situation in which the studentsare capable of keeping the interactions with the WBL systems on track. Control is a critical component that affects students' motivation, performance, and attitudes towards learning (Kopcha and Sullivan, 2008). Attention focus refers to the situation in which students are mentally absorbed into the WBL activities. Webster *et al.* (1993) defined curiosity as the situation in which studentsare excited and eager to know further about the domain knowledge. Intrinsic interests can be defined as a situation in which students enjoy the learning activities.

	Fully-guided WBL	Partially-guided WBL
Evaluation of prior knowledge	Both versions evaluated learners' prior knowledge	
Sequencing of learning contents	Sequencing of learning contents were automatically enforced as soon as evaluation of prior and current knowledge were completed	The system suggested the learning contents that should be learned after the evaluation of the respective prior and current knowledge were completed
Learners' access to the learning path	Learners were automatically presented with the sequence of learning contents and should follow the given learning path	Learners were expected to browse the suggested learning contents independently from the "Notes page" in the system

Table I. The features of the fully- and partially-guided WBL

Dimensions of engagement	
Control	Q1. When using the system, I felt in control over everything
	Q2. I felt that I had no control over my learning process with the system
	Q3. The system allowed me to control the whole learning process
Attention focus	Q4. When using the system, I thought about other things
	Q5. When using the system, I was aware of distractions
	Q6. When using the system, I was totally absorbed in what I was doing
Curiosity	Q7. Using the system excited my curiosity
	Q8. Interacting with the system has made me curious
	Q9. Using the system aroused my imagination
Intrinsic interests	Q10. Using the system bored me
	Q11. Using the system was intrinsically interesting
	Q12. The system was fun for me to use

Table II. The overall questionnaire

Four items from the extended questionnaire (i.e. one item for each dimension) were used in the short version as in Table III. The questionnaire used five-point Likert scale (i.e. 1 for strongly disagree and 5 for strongly agree).

3.4 Procedure

The experiment was conducted in unsupervised online mode. All materials were pre-programmed in a form of a computer system. All participants were given a URL (web link) to access the materials.

The tasks for the experiment were arranged in the following sequence. First, the participants were given with an information sheet, and they were required to sign a digital consent form. They were randomly assigned to either the fully-guided or the partially-guided WBL systems. Second, they were required to undergo a tutorial session. The learning session was divided into three stages. At the end of each stage, the participants were required to answer the short questionnaire.

Upon completion of the tutorial, the participants were asked to answer the extended questionnaire. All participants' interactions (e.g. clicking buttons and clicking hyperlinks) with the computer systems were automatically recorded in the database. The system was set to log off when the participants were inactive[1] for five minutes. The procedure is illustrated in a flow chart as in Figure 4.

4. Results

This study employed SPSS Version 18 for performing major statistical tests. Since the sample size was small, non-parametric statistical tests were used. This was also supported by a normality test (following the Kolmogorov-Smirnov (KS) method) that confirmed the data were non-normal.

The average age of the participants was 24.17 ranging between 17 and 45 years. Approximately 75 percent of the participants were students enrolled in IT course. Table IV displays the number of participants based on the two types of WBL systems and their programs at the university.

Table III.
The short questionnaire

Dimensions	Questions
Control	The system allowed me to control the whole learning process
Attention focus	When using the system, I was totally absorbed in what I was doing
Curiosity	Interacting with the system made me curious
Intrinsic interests	The system was fun for me to use

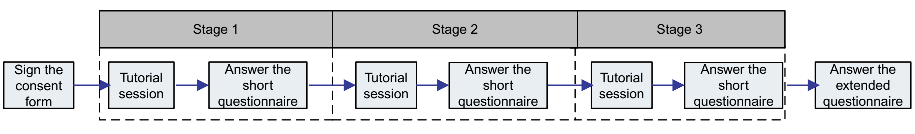


Figure 4.
Procedure for conducting the experiment

Table IV.
The participants' background

	Fully-guided	Partially-guided	Total
IT program	14	17	31
Non-IT program	7	3	10

4.1 The progression of engagement

The data for the short questionnaire had a relatively high internal consistency. The Cronbach's α coefficient for the four items[2] is 0.949.

In general, students in the partially-guided WBL system had positive progression of engagement. This can be seen through their average scores for the three stages (i.e. Stages 1-3). In contrast, the fully-guided WBL had showing a negative pattern of engagement. The engagement patterns for the two guided WBL systems are shown in a line chart in Figure 5.

A series of Mann-Whitney U tests suggested that the partially-guided scores for Stage 3 were significantly higher than the fully-guided ($z = -2.073$, $p = 0.018$, $p < 0.05$). As a great number of the participants in this research were students from IT program, their background of knowledge was analyzed to see if it has some effects on their level of engagement. The test results confirmed that the mean ranks for the IT students were significantly higher than the non-IT students in Stage 1 ($z = -2.188$, $p = 0.028$). Due to the small number of non-IT students in this study, it is insufficient to compare engagement between the IT and non-IT students. The result requires an extended study with a larger number of samples. Hence, the rest of the analysis has been focusing on comparing the IT students who used the partially- and fully-guided tool. No comparison was made between the two groups of students.

Looking into the students with high background of knowledge against the types of instructional strategies, the partially-guided IT students rated higher scores in all stages compared to the fully-guided IT students. In Stage 3, the Mann-Whitney U tests showed that the mean rank for the partially-guided IT students was significantly higher ($z = -2.070$, $p = 0.038$) than the fully-guided IT students.

The results of the study suggest that the partially-guided WBL system improved student engagement of the high background knowledge (i.e. IT knowledge) in comparison to the fully-guided one.

4.2 The overall engagement

The Cronbach's α coefficient for overall engagement was 0.799. The means and the means ranks for the overall engagement scores were calculated. Table V shows the

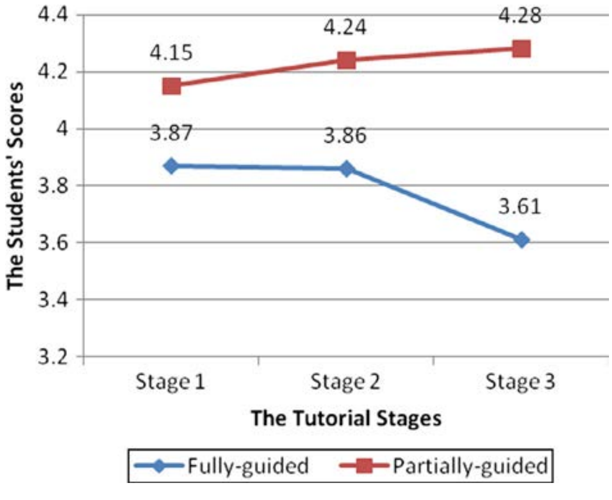


Figure 5.
Engagement patterns according to the students' self-report

mean and the mean ranks for the individual dimensions of the overall engagement. Analysis on these items showed that the partially-guided WBL system received a higher mean score (3.68) compared to the fully-guided (3.27). In terms of the individual dimensions, curiosity obtained the highest scores for both types of WBL with 4.17 and 3.63 for the partially- and fully-guided, respectively. On the other hand, attention focus was the dimension with the lowest scores for both types of WBL systems.

A series of Mann-Whitney *U* tests were performed to identify the difference in the overall engagement of the two WBL systems. The partially-guided students had significantly higher in their overall engagement scores than the fully-guided ($z = -2.714$, $p = 0.006$, $p < 0.05$). The test results also suggested that the partially-guided students rated higher for the control dimension compared to the fully-guided students ($z = -3.441$, $p = 0.000$, $p < 0.05$).

5. Discussions and conclusion

This study compared the effects of two web-based guided WBL systems; the fully-guided and the partially-guided on the students' engagement.

The results of this study suggest that the engagement was changing in unpredictable ways throughout the given guided WBL learning session. Although it is a common sense that individual engagement is dynamic; however, the results discussed herein have some important implications for adaptive design of guided WBL systems. The students' engagement was inconsistent in both types of the instructional strategies. The types of guided learning had differentiated the engagement. Obviously, the partially-guided WBL formed a positive change while the fully-guided formed a negative change in the engagement patterns. This outcome could be related to the way in which the learning content was presented to the students and as well as the students' prior knowledge. Further research is required to validate the relationship between engagement and content sequencing techniques.

The outcomes of the study have shown some different roles of guided instructions in shaping student engagement. The implications of this study are important in the context of adaptive WBL design. There are two aspects of the outcomes of this study. First, the study found that the fully-guided instruction is not always engaging. For this reason, the WBL should be designed in a way that it can support students with different background of knowledge flexibly. A possible solution to this is through a blend of fully- and partially-guided WBL systems that may foster adaptive learning for students regardless of their background of knowledge. Second, the WBL systems should also include a mechanism to foster engagement; or at least to maintain its consistency. This is important to ensure that students are always

Table V. The means and (mean ranks) for the individual dimensions of the engagement

Dimensions of engagement	Fully-guided ($n = 21$)	Partially-guided ($n = 20$)	Statistics values
Control (CO)	3.13 (14.81)	3.81 (27.50)	$z = -3.441$, $p = 0.000$, $p < 0.05$
Attention focus (AF)	2.79 (19.36)	2.95 (22.73)	$z = 0.937$, $p = 0.355$, n.s.
Curiosity (CU)	3.63 (17.50)	4.17 (24.68)	$z = -1.938$, $p = 0.052$, n.s.
Intrinsic interests (II)	3.52 (18.48)	3.80 (23.65)	$z = -1.403$, $p = 0.164$, n.s.
Overall engagement	3.27 (16.07)	3.68 (26.18)	$z = -2.714$, $p = 0.006$, $p < 0.05$

motivated to learn independently. It is anticipated that these two approaches would be of value in providing an adaptive learning environment and make learning more enjoyable.

Notes

1. The term "inactive" is the condition in which no interactions have happened between the student and the system (e.g. clicking the mouse or scrolling the browser's scroll bar) for five minutes or more.
2. The four items were described in Table III.

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