Incorporating Usability Criteria into the Development of Animated Hierarchical Maps

Yu-Cheng Shih¹, Pei-Ren Huang¹ and Sherry Y. Chen¹,2*

¹Graduate Institute of Network Learning Technology, National Central University, Taiwan // ²Department of Information Systems and Computing, Brunel University, United Kingdom // tearstains@cl.ncu.edu.tw // davidfirsttw@cl.ncu.edu.tw // sherry@cl.ncu.edu.tw

* Corresponding author

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ABSTRACT

Nowadays, Web-based learning systems have become popular because they can provide multiple tools, among which hierarchical maps are widely used to support teaching and learning. However, traditional hierarchical maps may let learners easily get lost within large information space. This study proposes an animated hierarchical map to address this problem. To consider the effects of different instructional approaches, we also conducted an empirical study to examine how learners in collaborative learning and those in individual learning reacted differently to the animated hierarchical map and traditional hierarchical map. A questionnaire, which was designed based on Nielsen’s heuristics, was applied to examine learners’ reactions to the proposed animated hierarchical map. The results show that the proposed animated hierarchical map is generally better than the traditional hierarchical map but the effects on individual learning is limited.

Keywords
Hierarchical map, Nielsen’s heuristics, usability, web-based learning

Introduction

Web-Based learning (WBL), which is showing explosive growth (Song, Wang, & Liu, 2011), is widely employed by worldwide corporations and universities (ChanLin, 2010). This is probably because WBL provides high flexibility (Chen & Macredie, 2010). For instance, the WBL allows learners to use multiple navigation tools to develop their own learning strategies. Among various navigation tools, hierarchical maps (HMs) are popular for learners because a graphic representation is used to give an overall picture (Nilsson & Mayer, 2002).

Several studies indicated that such an overall picture is beneficial for learners to build the global understanding of the subject content (Nielsen, 2000). It is probably due to the fact that such an overall picture can help learners construct logical relationships between each topic. In brief, learners can greatly benefit from the HM (Amadieu et al., 2010). However, such benefits only appear when the HM is well designed. Conversely, a massive HM may hinder learners to reach their learning objectives. For instance, learners may find it difficult to discover relevant issues if information is not systematically displayed in the HM. To this end, the design of the HMs should carefully consider usability, which can facilitate users’ interactions with systems and effectively reach the purposes of the systems (Graniča & Ćukušić, 2011).

In addition to taking into account usability, there is also a need to consider the requirements of different instructional approaches. Recently, WBL is not only applied to support individual learning, but also is employed to promote collaborative learning. Regarding individual learning, a learner develops learning strategies on his/her own (Johnson et al., 2010). Regarding collaborative learning, learners work together to develop their learning strategies so they can exchange ideas, perspectives, and arguments with each other (Pargman and Wærn, 2003). The differences between these two approaches lie within the fact that individual learning is the one in which learners work individually to reach their own objectives while collaborative learning is an instruction method in which more than an individual work together to reach their common objectives (Leidner & Fuller, 1997). In other words, individual learning and collaborative learning are different approaches so they have different requirements. Thus, there is also a need to consider these two approaches when we propose a new HM for WBL.

To this end, the study presented in this paper not only incorporates usability into the development of an animated HM, but also examines whether the animated HM can accommodate the requirements of collaborative learning and individual learning. It is our ultimate goal that such an animated HM can work as a benchmark for the improvement
of the design of WBL systems and other Web-based applications. By doing so, the performance and satisfaction of users who uses these applications can be enhanced.

**Theoretical background**

WBL systems offer multiple tools to help learners locate information effectively, including main menu, keyword search, hierarchical map, and alphabetical index. These navigation tools serve different purposes. A main menu is used to display a list of relate topics in a logical way. A keyword search supports learners to locate relevant information for a particular concept. A hierarchical map uses a graph to illustrate relationships among various topics. An alphabetic index is used to list all of topics in an alphabetic order (Khalifa & Kwok, 1999; Nilsson & Mayer, 2002; Chen & Macredie, 2004). Among these tools, the HM is popular in the WBL systems. This is due to the fact that the HM visualizes logical relationships among various topics with a graph (Majid et al., 2006). As indicated by Levin, Anglin and Carney (1987), combining texts with graphics is a useful instructional means, which can make verbal description more comprehensible and facilitate learners to understand a complex subject matter. In addition, the HM can present whole information within a single graph. As showed in the study by Danielson (2002), the HM can help learners get a global view so that learners can easily build logical relationships between each concept. Furthermore, previous studies found that the HM could reduce learners’ disorientation problems. For instance, Amadieu et al. (2009) found that HMs can help learners avoid getting lost because learners can easily identify their current status and reach their targets effectively.

Due to these benefits, several studies attempt to improve the development of HMs with advanced learning technologies, among which computer visualization and animation have been extensively used (Null & Rao, 2005; Holliday, 2003). Regarding computer visualization, an early study by Johnson and Shneiderman (1991) used an interactive visualization method to show large hierarchies within a limited space. Regarding animation, Dicheva, Dichev and Wang (2005) designed an interactive graphical user interface that combines a hierarchical layout with an animated view, where zoom-able views and click-able topics were provided. Furthermore, a recent study by Nesbit and Adesope (2011) produced an animated concept map in the form of a network diagram in which nodes and links are sequentially added or modified. These technologies bring a lot of improvements to HMs so we also attempted to use these technologies in our proposed animated HM.

However, the aforementioned studies ignore the importance of usability in the development of HMs. Usability is essential for the design of software development (Juristo et al., 2007) and that there is a close relationship between Web-based service quality and usability of Web-based information systems (Oztekina, Nikovb and Zaimc, 2009). As indicated by Van den Haak et al. (2004), usability is useful to improve information systems. They used usability to enhance online library catalogues. Moreover, Karahoca et al. (2010) used usability to improve the emergency department (ED) software prototypes developed for Tablet personal computers to keep electronic health records of patients errorless and accessible through mobile technologies. Recently, Harvey (2011) used usability to improve toolkit for In-Vehicle Information Systems (IVIIs). Additionally, a framework is presented to guide designers through defining usability criteria for an evaluation, selecting appropriate evaluation methods and applying those methods.

The aforesaid studies demonstrate the importance of usability. Due to such importance, several studies also proposed criteria for the assessment of usability. Among various criteria, five criteria proposed by Nielsen (1993), i.e., “Efficient to use,” “Easy to learn,” “Few errors,” “Easy to remember” and “Pleasant to use,” are widely employed to assess usability. For instance, Yeung and Law (2004) applied these five criteria to improve the usability of hotel websites in Hong Kong. On the other hand, these five usability criteria were also included in the criteria of other studies. For example, Campbell (2003) indicated that usability criteria should follow by easy to learn, easy to use, easy to remember, error tolerant, subjectively pleasing. Another study by Brinck (2002) claimed that usability criteria should consider correct functionality, efficient to use, easy to learn, easy to remember, error tolerant, subjectively pleasing. An early study by Wixon (1997) claimed that usability criteria should include learnability, efficiency, memorability, satisfaction, flexibility, first impressions, advanced feature usage, resolvability. Because of the significance of these five criteria, we not only incorporate usability into the development of our proposed animated HM, but also use these five criteria to assess the usability of this HM. The novelty of our study is due to this approach, which is different from the aforementioned studies.
In addition to this novelty, this study also considers the requirements of different instructional approaches because many new instructional approaches have appeared in current educational settings in the past ten years. In particular, collaborative learning is widely used to support teaching and learning. For example, Tolmie et al. (2010) used collaborative learning to supported learners in science training, in which learners are grouped to collaboratively work in the context of two science topics, i.e., forces and evaporation. Another study by Prichard et al. (2006) used collaborative learning to supported learners in team-skills training, in which training objectives include problem solving, planning, decision making, setting objectives, time management, agreeing roles, creating a group environment and cooperation. Moreover, the study by Mukama (2010) used collaborative learning to support university students to develop hands-on computer skills and knowledge in small task-based groups.

Conversely, individual learning is different from collaborative learning. Gokhale (1995) clarified the differences between these two approaches. He thought that collaborative learning is an instruction method in which students work in groups toward a common academic goal while individual learning is the one in which students work individually at their own level and move toward an academic goal. These two approaches also have different advantages. Collaborative learning can lead to deep information processing (Kirschner et al., 2009a) and stimulate and enable learners to engage in activities that are valuable for learning (Kirschner et al., 2009b). In contrast, individual learning makes learners autonomously cover all aspects of a learning task and exercise argumentative learning activities at their own pace (Weinberger et al, 2010). Additionally, learners have to mentally interrelate multiple external representations to understand the learning material and the underlying concepts by themselves (Bodemer, 2011). Because of such differences between collaborative learning and individual learning, we also conduct an empirical study to investigate whether the proposed animated HM can accommodate the needs of students who use collaborative learning and those who use individual learning.

**Methodology design**

The aims of this study are two-fold: (a) to propose an animated HM for large information space and (b) to assess the proposed animated HM by conducting empirical research. As described in the previous section, there is a need to consider different instructional approaches. Thus, the empirical work not only compares the effects of the traditional HM and the proposed animated HM, but also investigates how learners with collaborative learning and those with individual learning react differently to the traditional HM and the proposed animated HM. The details are described in subsections below.

*Design of an animated hierarchical map*

To achieve the first aim, we initially assess the usability of existing HMs based on five main criteria proposed by Nielsen, i.e., “Efficient to use,” “Easy to learn,” “Few errors,” “Easy to remember” and “Pleasant to use.” The results of the assessment show that the existing HMs have several shortcomings (Table 1). To address these shortcomings, we explore some potential solutions, which are described in Table 1.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Objectives</th>
<th>Existing Shortcomings</th>
<th>Proposed Solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to remember</td>
<td>Learners can still recall its general structure though they do not use a system for a while.</td>
<td>Massive information is presented so it is difficult to remember where to locate information.</td>
<td>The content is divided into several main sections, each of which includes a number of sub-sections. The subsections can be hidden.</td>
</tr>
<tr>
<td>Easy to learn</td>
<td>Learners can quickly understand how to explore the subject content.</td>
<td>Learners need to keep using a scrolling bar to seek additional information.</td>
<td>Information is presented within one page so there is no need to use a scrolling bar.</td>
</tr>
<tr>
<td>Efficient to use</td>
<td>Learners can quickly orient themselves and identify a right direction to achieve learning</td>
<td>There is a lack of clear visual cues so learners feel difficult to know</td>
<td>Additional visual cues are used to help learners identify their current location.</td>
</tr>
</tbody>
</table>

Table 1. The shortcomings of existing hierarchical maps and potential solutions
Regarding the shortcomings of existing HMs, massive information is presented (Figure 1) so learners may easily get lost. To address this problem, we use Adobe Flash to develop an animated HM (Figure 2 and Figure 3) based on the solutions described in Table 1. The animated HM show eight main sections and then learners can use left and right arrow keys to choose a particular main section, of which subsections are displayed above the main section chosen. In
other words, other sub-sections are hidden. By doing so, the animated HM presents a clear structure, which can be *easy to remember*. Due to the fact that the screen only shows eight main sections and the subsections of the main section selected, all of the subject content can be displayed within one page. Thus, there is no need to use scrolling bar so that students may feel it is *easy to learn* how to use the animated HM.

Furthermore to the abovementioned left and right arrow keys, another arrow key placed in the middle side is applied to point out the main section chosen so that students can clearly identify their current location, which, in turn, they *feel efficient to use* the animated HM. In addition to the chosen main section, the selected subsections are also highlighted with yellow lines so that students can correctly select relevant subsections and *make few errors*. In summary, arrow keys are employed to switch the HM with animations, which students may *feel pleasant to use*.

**Empirical work**

To achieve the second aim, an empirical work was conducted and the detailed design of the empirical work is described below.

**Participants**

30 undergraduate and graduate students voluntarily took part in our empirical work. To recruit these participants, a request was issued to students in lectures, and further by email, which indicated that all participants had to have the basic computer and Internet skills to access a WBL system but they should not have taken any courses related to the subject content of the WBL system before they participated in our study.
Web-based learning system

In this empirical work, the WBL system presents the principles of “Interaction Design” and includes eight sections. Either the animated HM or the traditional HM is used as an entry point to go into the main content of each section. The screen design consists of (a) a title bar used to present the subject of the WBL system, (b) a MAP button placed in the left hand side and corresponded the animated HM or the traditional HM to help learners locate information from the WBL system, and (c) the main content of the WBL system (Figure 4).

Figure 4. The Web-based learning system

Design of a questionnaire

A questionnaire was used to identify whether learners were satisfied with the proposed animated HM because it is useful to investigate learners’ perception (Kinshuk, 1996). The questionnaire was designed with open questions, which can allow participants to express their opinions with their own words. The design rationale of the questionnaire was based on the aforementioned criteria listed in Table 1. To this end, seven open-questions are included in the questionnaire. The examples of the questions are presented in Table 2.

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>How do you think about the efficiency of these two types of hierarchical map. More specifically, which map can let you quickly locate relevant information? Please also give the reasons why you think that this map is more efficient</td>
</tr>
<tr>
<td>2</td>
<td>Please describe your experience in using these two types of hierarchical map. In particular, please identify which map you feel easy to use and give the reasons for your choice.</td>
</tr>
<tr>
<td>3</td>
<td>Please describe your perception to the design layout of these two types of hierarchical map. In particular, please identify which map you feel pleasant to use and give the reasons for your choice.</td>
</tr>
</tbody>
</table>

Post-test

As described in the Methodology Section, all of the participants did not have any prior knowledge of the subject content so only a post-test was applied to assess how much they have learnt from the WBL systems, instead of using both of the pre-test and the post-test. The post-test was presented in a computer-based format and included 20 multiple-choice questions. Each question included three different answers and an “I don’t know” option but there was only one right answer. The questions covered all eight sections of the WBL system from basic concepts to advanced topics and the answers could be obtained by using both of the traditional HM and the animated HM. Students were allotted 20 minutes to take the post-test and were not allowed to examine the content presented in the system when they took the post-test.

Experimental procedures

The participants were divided into two types of learning settings, i.e., collaborative learning and individual learning, in a random way. For each setting, all of the participants need to use both the traditional HM and the animated HM.
By doing so, we could examine the effects of these two types of maps on individual learning and collaborative learning.

Regardless of the traditional HM and the animated HM, the participants were also required to complete some practical tasks when they interacted with the WBL system. The tasks included 20 factual questions, which focused on a single concept and there was only one standard answer for the question. The participants needed to find answers for these questions from the WBL system. More specifically, the purpose of performing these tasks was to offer the opportunities of experiencing interface features provided by the traditional HM and the proposed animated HM. Subsequently, they had to take the post-test, which was used to assess how much they had learnt from the WBL system. In other words, the post-test scores were used to identify their learning performance. Finally, the participants needed to fill out the questionnaire to express their perception to the design of the proposed animated HM and the traditional HM.

**Data analysis**

Two independent variables are included this study. One is related to the design of HMs (i.e., the animated HM and the traditional HM), and the other one is concerned with learning settings (i.e., collaborative learning and individual learning). There are also two dependent variables. One is learners’ performance, which is assessed by their post-test scores. The other one is learners’ perception, which is identified by their responses to the questionnaire.

**Results and discussions**

**Learning performance**

Figure 5 presents the learning performance of students using the traditional HM (mean = 5; standard deviation = 1.49) and the proposed HM (mean = 5.75; standard deviation = 1.40) in individual learning. Figure 6 presents the learning performance of students using the traditional HM (mean = 5.17; standard deviation = 0.75) and the proposed HM (mean = 7.17; standard deviation = 1.83) in collaborative learning. The result from the Independent t-test shows that there is no significant difference between the students using the traditional HM and those using the proposed HM in individual learning (p > .05). It implies that the two maps have similar effects on individual learning. On the other hand, the result from the Independent t-test shows that there is significant difference between the students using the traditional HM and those using the proposed HM in collaborative learning (p < .05). More specifically, students who used the proposed animated HM could get better learning performance than those who used the traditional HM in collaborative learning. This finding suggests that the proposed animated HM is useful to enhance students’ learning performance in collaborative learning.

![Figure 5. Students’ performance in individual learning](image-url)
In summary, the proposed animated HM is not very helpful for individual learning but it is beneficial to enhance students’ learning performance in collaborative learning. The difference between individual learning and collaborative learning lies within the fact that each individual builds his/her learning strategies by himself/herself in the former while individuals work together to build their learning strategies in the latter. Thus, social exchange among various individuals may be a key factor for collaborative learning (Schnotz, Bockheier & Grzondziel, 1999). The above mentioned results suggest that the proposed animated HM may be a useful social exchange tool for students.

Table 3 presents the strengths and weaknesses of the traditional HM and the proposed animated HM for individual learning and collaborative learning based on learners’ responses to the questionnaire.

### Table 3. The strengths and weaknesses of the traditional hierarchical map and the proposed animated hierarchical map

<table>
<thead>
<tr>
<th></th>
<th>Individual Learning</th>
<th>Collaborative Learning</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Traditional hierarchical</strong></td>
<td><strong>Strengths</strong></td>
<td><strong>Weaknesses</strong></td>
</tr>
<tr>
<td>Map</td>
<td>To easily get a global picture of the subject content</td>
<td>To provide too much unnecessary information.</td>
</tr>
<tr>
<td></td>
<td>“The map presents information in a tree-based structure, which is efficient for a learner who intends to get the global picture of the subject content initially.”</td>
<td>“The map provides comprehensive information within tree-based structure but too much unnecessary information lets me feel overwhelmed.”</td>
</tr>
<tr>
<td></td>
<td>Highly efficient with back / forward buttons</td>
<td>Increased Cognitive Overload</td>
</tr>
<tr>
<td></td>
<td>“The map is highly efficient because we can explore the content with the back/forward buttons provided by the Microsoft Internet Explorer.”</td>
<td>“I feel difficult to remember the content that I have visited because such a big picture increases the overload of my memory.”</td>
</tr>
<tr>
<td></td>
<td><strong>Weaknesses</strong></td>
<td><strong>Easy to get Lost</strong></td>
</tr>
<tr>
<td></td>
<td>To provide too much unnecessary information.</td>
<td>We may go to a wrong direction for my learning goals and even forget what I have learnt when I go into the next section.”</td>
</tr>
<tr>
<td></td>
<td>“The map illustrates the relationships among all topics so it includes too much irrelevant information.”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Easy to get Lost</td>
<td>**To provide too much irrelevant information.”</td>
</tr>
<tr>
<td></td>
<td>“We may go to a wrong direction for my learning goals and even forget what I have learnt when I go into the next section.”</td>
<td></td>
</tr>
</tbody>
</table>

Learning perception

Table 3 presents the strengths and weaknesses of the traditional HM and the proposed animated HM for individual learning and collaborative learning based on learners’ responses to the questionnaire.
<table>
<thead>
<tr>
<th>Proposed animated hierarchical Map</th>
<th>Strengths</th>
<th></th>
<th>Weaknesses</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Easily to concentrate on the subject content</td>
<td>“This map can make learners easily concentrate on the subject content than the other type of map.”</td>
<td>Difficult to get the overview of the subject content</td>
<td>“It is hard to grasp an initial picture of each topic at an early stage because only one topic is displayed at a time.”</td>
</tr>
<tr>
<td></td>
<td>To provides a friendly graphic-based user interface</td>
<td>“The map outperforms the other type of map because it provides a friendly graphic-based user interface.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clear Structure</td>
<td>The structure is clear because only one topic is showed at a time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To systematically go to the sub-level of categories</td>
<td>“The map provides options to explore the subject content in a systematic way.”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To easily remember the past learning path</td>
<td>“I can easily remember where I have been in the map because the map presents clear structure.”</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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</tbody>
</table>

**Individual learning**

Most of learners in individual learning think that the traditional HM can present the complete information of the subject content at a time so learners can easily get an overall picture at an early stage. It may be because the traditional HM utilizes a tree-based structure, which allows students to easily grasp an overall picture. Conversely, the traditional HM provides massive information. Such massive information may be irrelevant to learners’ tasks so they may experience cognitive overload, which may hinder them from reaching their learning goals (Chen et al., 2009). Additionally, learners are provided with too many choices so learners may feel difficult to select right information for their tasks.

Regarding the proposed animated HM, most of learners in individual learning think that the proposed animated HM is useful to examine a single topic deeply. It may be because the subject content is well classified and presented in a systematic way. This is also the reason why the learners value the proposed animated HM. Moreover, the proposed animated HM can not only present sufficient information within one page but also the size is not as big as the traditional HM. Consequently, they think that the proposed animated HM offers a friendly interface and feel easy to use the proposed animated HM. However, the proposed animated HM still has some disadvantages. In particular, learners may have difficulties to grasp an initial overview of each topic at an early stage. It may be because the subject content has been divided into eight sections and only one section is displayed at a time. Therefore, they have to switch between each section and connect different topics by themselves if they need to get a completing understanding of the subject content.

**Collaborative learning**

Most of learners in collaborative learning think that using the traditional HM is efficient to switch between each topic so that they can easily locate relevant information. It may be because the traditional HM supports non-linear navigation with the backward/forward buttons provided by a browser. Such an advantage only exists when the map is compatible with the browser. As described in the previous section, the traditional HM, however, presents too much information so that learners may feel difficult to reach their learning goals. In addition, such a complex structure may lead learners to go to a wrong direction so that they have to spend much time finding relevant information for their tasks. Therefore, they cannot concentrate on their learning tasks.
On the other hand, most of them think that the proposed animated HM is well-structured so that they can explore the subject content step-by-step. A possible reason is that the subject content is divided into eight main sections in the proposed animated HM and the subsections are displayed above these eight main sections. However, learners may find it tedious to use the proposed animated HM. It may be because the proposed animated HM is not supported by the backward/forward buttons provided by a browser. Thus, they have to start from the first page every time when they need to go back to the previous section. This is also the reason why learners indicated the proposed animated HM is not as efficient as the traditional HM.

In summary, the results presented in this section indicate that our proposed animated HM does not have remarkable effects on individual learning while it can have greatly positive effects on collaborative learning. As described in the Theoretical Background Section, the difference between the individual learning and collaborative learning lies within the fact that only one student is involved in the former whereas more than one student are engaged in the latter. More specifically, discussion may take place in collaborative learning. Students may have diverse interests so that there is a need to have a tool to facilitate their discussion. The traditional HM presents massive information so students may find it difficult to share their interests. On the other hand, our proposed HM provides a well-structured categorization to help learners identify their interests. Furthermore, an arrow in the middle of the proposed animated HM works as a visual cue, which is useful to understand the interests of each other. In brief, our findings suggest that the proposed HM can enhance students’ communication in collaborative learning. Conversely, discussion does not take place in individual learning so the effects are limited.

Regardless of individual learning or collaborative learning, learners generally not only show more positive perception in using the proposed animated HM, but also demonstrate a better performance. These findings are in line with those of previous studies (Chen, 2002; Frias-Martinez et al., 2008), which highlighted that there was a close link between students’ learning perception and learning performance. More specifically, positive perception could enhance learners’ performance. These results reinforce the importance of a good design, which can not only enhance students’ learning performance, but also improve their learning perceptions.
Session 1
Usability of Interaction Design

Figure 8. Zooming in Hierarchical Map

Figure 9. The stretch text of the hierarchical map
Implications for the design of navigation tools

The results presented in this paper indicate that the proposed animated HM is generally appreciated by students. However, some weaknesses still exist so there is a need to improve the proposed animated HM. Firstly, students think that it is difficult to get an overview with the proposed animated HM at an early stage, regardless whether it individual learning or collaborative learning. One of the solutions to address this problem is to allow the learners to see an overall picture with the functionalities of zooming out and zooming in. More specifically, zooming out is to shrink each section of the map so that all of the sections can be displayed within the map (Figure 7). In contrast, zooming in is to magnify a section of the map so that the details of this section can be examined (Figure 8). In other words, the former is useful to show all topics for students who would like to get a global picture of the subject content. Conversely, the latter is helpful for students who would like to examine a single topic deeply. By doing so, zooming out can overcome the weaknesses of the proposed animated HM while zooming in can still keep the strengths of the originally proposed animated HM.

On the other hand, the results of our study showed that the traditional HM provided too much irrelevant information so students might experience cognitive overload. This is due to the fact that all of the topics are displayed within one map. The abovementioned zooming out may also help students address this problem, which can be solved by stretch text. More specifically, the map initially presents main sections only. When learners move the mouse to a particular main section where they are interested, a type of stretch text is used to present various subsections associated with this main section. Conversely, these subsections can also be hidden when the students intend to examine a single topic deeply (Figure 9). In other words, this approach increases the flexibility of the proposed animated HM so that learners can easily get a global picture of the subject content and examine a particular topic in details.

Conclusions

To address the problems of the traditional HM, this study proposes an animated HM. One of the advantages is that Adobe Flash was applied to create animations so that learners can switch between each section easily. The other advantage is that the proposed animated HM was carefully designed based on Nielsen’s five usability criteria, including “Efficient to use,” “Easy to learn,” “Few errors,” “Easy to remember” and “Pleasant to use.” An empirical study was conducted to investigate the effects of this proposed map on individual learning and collaborative learning. The effects of the proposed map on individual learning are not as obvious as collaborative learning. Nevertheless, learners positively reacted to the proposed animated HM in general. This suggests that incorporating usability criteria into the development of the animated HM can overcome shortcomings in the traditional HMs to satisfy users’ needs (Marsico & Levialdi, 2004).

Thus, this study contributes to the deep understanding of how to incorporate usability into the development of the HM. Furthermore, the design rationale can also be applied to develop other navigation tools, e.g., main menu. However, the proposed animated HM still has some weaknesses. Thus, several additional design approaches were proposed to address these weaknesses. In the future, the rationale of the design approaches can be used to improve the development of existing WBL systems and other Web-based applications, such as digital libraries, search engines, and electronic journals. Finally, it would be valuable to see whether learners’ performance and perception can be improved in such WBL systems and the Web-based applications.

Although this study shows fruitful results and proposes useful solutions for the improvement of the design of WBL systems and the Web-based applications, some limitations still exist. Firstly, this is a small-scale study. In the future, there is a need to conduct an empirical study with a large sample from a generic case. Furthermore, WBL systems are used by diverse learners. Therefore, further works should examine how individual differences affect learners’ preferences for the design solutions proposed in this study. The results from such further works can be incorporated into those of the present study so that a robust user model can be built for the development of personalized WBL systems.

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