The Effects of the E-Book System with the Reading Guidance and the Annotation Map on the Reading Performance of College Students

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ABSTRACT
Novice learners demonstrate marked difficulty in using reading-study systems to read academic textbooks. One notable problem is that the process and constructed knowledge is complex. Novice learners are required to exert considerable effort in applying the process and in remembering the knowledge, resulting in lower motivation and fewer cognitive resources for reading. This study develops an e-book reading system with an integrated reading guidance module and an annotation map, and conducts an experiment for examining the effect of this system on reading, reviewing, navigational performance, and reader behavior. The results show that the annotation map significantly improves reviewing and navigational performance, but not reading performance. Log analysis identifies two problems related to reading guidance: time allocation and learner control. We discuss these results and propose recommendations for future works.

Keywords
E-Book, SQ3R, Annotation, Reading guidance

Introduction
Reading is a vital skill. Students with proficient reading skills have the potential to become enhanced self-regulated learners and, thus, demonstrate high academic achievement. However, most students are not proficient in reading. Many students even lack the basic reading skills necessary to perform future job-related tasks (Artis, 2008), which will greatly affect their future study and work.

Several reading-study strategy systems provide clear guidelines to help students learn and practise techniques that imitate the behaviors of highly proficient readers (e.g., SQ3R, 3R, and KWL; Al-Khateeb & Idrees, 2010; Artis, 2008; McDaniel, Howard, & Einstein, 2009; Robinson, 1970). SQ3R, which consists of five steps (surveying, questioning, reading, reciting, and reviewing), is the most popular reading-study system and was primarily designed for expository text, particularly academic textbooks.

Although SQ3R is a purposeful and meaningful reading method in which students practise different reading strategies, it is cumbersome for novice learners to learn and use (Flippo & Caverly, 2000; Huber, 2004). The SQ3R process is complex, and the knowledge constructed during this process is comprehensive and varied. Novice learners must expend more cognitive and behavioral effort in operating and managing the process and knowledge before they become experienced. Their effort may impede reading comprehension when learners are unfamiliar with this method. This impediment may lower their motivation for using and practising this strategy (Artis, 2008).

Because the SQ3R process is complex, novice learners must use more cognitive resources to remember the SQ3R steps, when to use these steps, what purpose each step has, and how to perform each step. Although training and practice can facilitate the learning process, it consumes time and effort. Teachers typically address this method for a brief period and ask students to use it by themselves after class.

The learning products that are constructed and acquired during the SQ3R process are comprehensive and varied: section titles, keywords, an overview in the surveying step, questions in the questioning step, comments and crucial points in the reading step, and summaries in the reciting step. The relationship among the products forms a hierarchical structure. For example, when creating a question for a section title, several pieces of highlighted text and comments are generated to answer the question or explain a keyword, and a summary is written for the section. The hierarchical structure is useful for remembering and reviewing the learning products. However, they are distributed among different pages, and students have difficulty perceiving and remembering the structure and relationship.
This study designed an e-book reader that integrates SQ3R reading strategies with two scaffolding tools, a reading guidance module, and an annotation map, to solve the previously mentioned problems. The reading guidance module reminds readers of the purpose and task of each SQ3R step and provides examples for imitation. The annotation map, which integrates the annotations distributed among different pages into a hierarchical structure, is designed to support reading, reviewing, and navigating. In addition, we conducted an experiment to determine the effect of this e-book reader on the reading behavior and performance of readers.

**Related works**

*Reading strategies and SQ3R*

Reading strategies, which play a vital role in reading comprehension, have been recognized as effective approaches in increasing reading comprehension (Huang, Chern, & Lin, 2009). Successful readers apply several reading strategies for reading comprehension, such as recognizing text structure, posing questions, reflecting on behavior or the process, monitoring comprehension, organizing graphs, taking notes, and rereading (Sung, Chang, & Huang, 2008; Yang, 2006). Teaching every student to master these strategies in general courses is challenging. Therefore, several methods that bundle a set of reading strategies provide easily applied guidelines for students to practice independently during their reading processes.

SQ3R is the most popular reading method. Robinson (1970) developed this method by incorporating several higher-level study strategies consisting of five steps: surveying, questioning, reading, reciting, and reviewing. The surveying step involves skimming section headings and subheadings to identify chapter content, thus assisting readers in understanding the structure of the chapter. In the questioning step, readers ask questions based on headings and subheadings and transform the headings into questions to guide their reading. The reading step involves reading the text to answer the questions. In the reciting step, readers recall the answers and crucial points in the chapter. In the fifth step, readers reflect on the original questions and answers, organize relevant information, and review the information repeatedly.

Previous studies have investigated the effects of SQ3R on reading comprehension. However, the sparse evidence of the efficiency of SQ3R is inconsistent (Baier, 2011; Cantu, 2006; Carlston, 2011; McCormick & Cooper, 1991). For example, Baier (2011) observed that SQ3R significantly improved the overall comprehension scores of fifth grade students reading expository texts. However, Cantu (2006) found that the SQ3R learning method demonstrated little or no improvement over traditional learning methods. Such inconsistency may result from the varying material, instruction, task demand, or student variables (Flippo & Caverly, 2000).

Although insufficient evidence exists to prove that the SQ3R system is an effective reading strategy, it remains the most popular method among teachers. SQ3R imitates the reading patterns of proficient readers, provides useful examples for poor readers to improve, and gives meaning and purpose to reading. SQ3R techniques, such as questioning and summarizing, have also been separately proven to enhance reading comprehension and may foster in students a familiarity with the techniques.

*Scaffolding*

Scaffolding is a process in which assistance is provided to students when needed, and gradually reduced when their competence increases (Molenaar, Roda, Boxtel, & Sleegers, 2012). There are two types of scaffolding: static and dynamic. Static scaffolding is the same for all students and remains constant over time, whereas dynamic scaffolding involves analyzing student behavior to provide the most appropriate assistance. Previous studies have compared the advantages among dynamic, static, and no scaffolding, revealing that dynamic scaffolding yields greater benefits than does static scaffolding; however, static scaffolding provides more advantages than does no scaffolding (Azevedo, 2005; Azevedo, Cromley, & Seibert, 2004; Moos & Azevedo, 2008). Although dynamic scaffolding provides more advantages than static scaffolding does, dynamic scaffolding is difficult for teachers to implement and has been successfully applied only in structured domains (Li & Chen, 2009). In ill-structured domains, developing student models is difficult.
Previous studies have developed different scaffolding tools for self-regulated learning; however, few studies have developed tools to support SQ3R. Several studies have developed useful systems to support reading-study systems. For example, Kozminsky (2010) designed a system that provides several graph organizers for students to organize learning products during the SQ3R reading process. Zhang, Cheng, Huang, and He (2002) designed a distance-learning support system that helps students perform the SQ3R process by providing various tools such as a material map to assist students in browsing as well as memo tools to help students ask questions. However, these studies have not evaluated their levels of effectiveness.

Annotation

Annotation is a useful technique for adding information to existing documents and allows users to extend the meanings and contexts of textbooks (Glover, Xu, & Hardaker, 2007). Annotation consists of two types: marking (i.e., underlining or highlighting) portions of text and writing notes in margins or between lines (Ovsiannikov, Arbib, & McNeill, 1999). Marking text, which identifies key parts of the document, is the most frequently used reading aid (Ovsiannikov, Arbib, & McNeill, 1999) and serves as three functions to support text reading. First, marking text is an encoding process that identifies which parts are relevant and which parts are not. Second, marked text plays the role of visual signaling and can guide attention and reduce unnecessary visual searching when readers revisit the text. Third, marked text can be seen as a contextual cue associated with the text in learning materials. Contextual cues can help readers to recall the content and context of the marked text.

With the rapid growth in the number of digital learning materials, numerous annotation systems have been developed to support annotation by using PCs, the Web, and mobile phones (Glover, et al., 2007; Hoff, Wehling, & Rothkugel, 2009; Ovsiannikov, Arbib, & McNeill, 1999; Rau, Chen, & Chin, 2004). Except for basic annotation functions (e.g., highlighting text and adding notes), several annotation systems also support shared annotation (Wolfe, 2008), multimedia annotation (Hwang, Wang, & Sharples, 2007), and annotation management (Li & Chen, 2010). Although these annotation systems provide comprehensive and varied functionalities to support reading, they are not integrated with reading strategies, particularly the SQ3R strategy.

System design and implementation

To solve the identified problems, we developed an e-book system. The e-book reader interface is divided into three sections: the e-book, annotation map, and guidance section (Fig. 1). The e-book section presents the e-book content. The annotation map section allows students to develop and organize annotations into a hierarchical structure. The guidance section presents the SQ3R steps in sequential buttons.

Three modules were designed for this system: annotation, annotation map, and reading guidance. The annotation module provides basic annotation functions consisting of underlining, highlighting, and commenting. The annotation map module supports students in creating and organizing annotations.

Five types of tree nodes can be created in the annotation map section: heading nodes, which represent the underlined section titles and keywords in the surveying step; questioning nodes, which represent notes associated with the questions created for section titles in the questioning step; highlighting nodes, which represent the highlighted text segments created in the reading step; commenting nodes, which represent the notes made during the reading step; and reciting nodes, which represent the notes associated with summaries created for the sections in the reciting step. The node icons are represented with their respective annotation functions for students to identify the role of each node easily.

Highlighting or underlining a piece of information and organizing it into a hierarchical structure is simple. When marking a within-page text segment, a student can use a PC mouse to right-click a node in the annotation map section to access a context menu. The student can click the Heading or Highlight menu item and immediately underline or highlight this marked text segment. A heading node or highlighting node with a title assigned by students is generated under this clicked node. The student can also click the Question, Comment, or Recite menu item to generate a questioning, commenting, or reciting node.
The reading guidance module guides students to read by using five buttons: survey, question, read, recite, and review (Fig. 1). Before a student reads a chapter, the survey button can be activated. When the student presses the survey button, a message informs students of the purpose of this step and shows how to perform this step. When turning to a page that includes a section title or keyword, a student can mark it and click the Heading button presented above the annotation map section or the Heading menu item on the context menu, which is raised when right-clicking an existing heading node. The marked text is then immediately underlined, and a heading node representing the underlined section title or keyword is immediately added to the first level of the hierarchical structure or below the clicked heading node. After completing this step, the student can press the question button to enter the questioning step.

In the questioning step, a student generates questions for the section/subsection titles or keywords. The student can click the Question menu item on a heading node and a question form is presented for the student to enter the title and description of the question. A question node representing the question is created below the heading node, and a question picture associated with the question node is added to the page on which the section title exists.

When pressing the reading button, the student can read the pages in the first section and click the Highlight menu item to highlight a text segment or Comment to take notes. A highlighting node with a title assigned by the student or a commenting node is generated under the node in which the context menu was raised. After completing the reading step, the student can press the recite button. In the reciting step, students create a reciting node. Creating a reciting and commenting node is the same as creating a questioning node, and creating a highlighting node is the same as creating a heading node. Finally, the student can use the annotation map to review the content by double-clicking a node to go to the corresponding page.

This e-book system provides several types of static scaffolding to guide students during the SQ3R reading process. Table 1 lists these types of scaffolding.
Table 1. Scaffolding strategies used in the system

<table>
<thead>
<tr>
<th>Scaffolding</th>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructing</td>
<td>Reading guidance</td>
<td>The descriptions in each step explain the purposes and instruct students in how to perform the task.</td>
</tr>
<tr>
<td>Modeling</td>
<td>Reading guidance</td>
<td>The SQ3R process models how a proficient reader reads a textbook. The examples provided in each step teach readers how to conduct each SQ3R step.</td>
</tr>
<tr>
<td>Cognitive structure</td>
<td>Reading guidance and annotation map</td>
<td>The full process and current step is presented in the guidance section, which guides readers to read in a disciplined manner. The annotation map facilitates visualizing the products of the SQ3R knowledge construction process.</td>
</tr>
</tbody>
</table>

Method

The proposed e-book reader primarily involves two modules: reading guidance and an annotation map to support the SQ3R reading process. The reading guidance module, which consists of the scaffolds of instructing, modeling, and cognitive structure, reminds readers of the steps and purposes of SQ3R and demonstrates examples to help readers perform these steps. Therefore, the first question we would like to examine is whether the reading guidance module can effectively guide readers complete the SQ3R process.

The annotation map organizes the annotations created when using SQ3R in a hierarchical structure. Organizing learning products is a generative process that helps students effectively retain and recall information from long-term memory. The annotation map also reminds readers which annotations were created, including information regarding their relationships. When a reader must compare or synthesize information between pages, they can refer to this map without navigating between pages. We anticipated that the annotation map would be able to help readers remember and understand the content of particular textbooks. Therefore, the second question we sought to answer is whether the annotation map improves reading, reviewing, and navigational performance.

To answer the two questions, a quasi-experiment was conducted. In addition, we also executed a separate study in which a questionnaire and an unstructured interview were conducted to understand thoroughly student perceptions and levels of satisfaction regarding the use of such a system.

Study one: The quasi-experiment

Design

To answer Questions 2, a quasi-experiment was conducted. The between-subjects factor was the e-book reader system (i.e., the systems with reading guidance [S1] and with reading guidance and annotation map [S2]). Five dependent variables were used to examine annotation map effectiveness on reading and navigational performance: the score for reading comprehension after reading, the score for reading comprehension after reviewing, the time spent for navigational tasks, the number of pages visited for completing navigational tasks, and the number of navigational tasks completed in two attempts. We also used system logs to answer Question 1.

Participants

Forty-one first-year computer science undergraduate students recruited from National Central University in Taiwan participated in this experiment. Each participant was paid US$10 for participating. All of the participants had studied the Fundamental Computer Science course for two months. A total of 21 participants were in the S1 group and 20 participants were in the S2 group. Because prior knowledge can affect learning achievement, the participants were stratified into five levels, based on their mid-term exam scores in this course (the mid-term exam was conducted one week before the experiment) and were then randomly assigned to two groups based on the strata. No significant effect on mid-term exam scores ($t = -0.259, p = .797 > .05$) was observed between the S1 group (Mean = 86.76, SD =
9.68) and the S2 group (Mean = 87.60, SD = 11.04). Therefore, the two groups had the same level of prior knowledge.

**Materials**

The materials consisted of two reading systems (S1 and S2), two reading materials, two comprehension test questionnaires, and a paper handout. The language used in these materials was Mandarin Chinese.

The S1 group used our system without the annotation map section. The annotation functions for the respective steps were provided in a toolbar above the e-book section. The S2 group used our system.

The reading materials were extracted from a textbook from Fundamental Computer Science. Chapter Three, “Data Storage,” was selected as practice material. Chapter Five, “Computer Organization,” was selected as the experimental material and included 24 pages. We extracted 17 pages, which could be finished within 60 minutes.

The paper handout consisted of nine task descriptions (Tasks 1–9). Each description in Tasks 3, 6, and 9 was a picture (which was extracted from the reading material) for the participant to locate. Each description in Tasks 1, 4, and 8 was a paragraph extracted from a specific web page that participants had to locate. Each description in Tasks 2, 5, and 7 was a keyword for which the participants had to locate the definition.

Two comprehension tests, one for reading and one for reviewing, were used to evaluate reading performance. The comprehension test included ten open-ended questions for reading, consisting of four remembering, four comprehension, and two application questions. The comprehension test for reviewing comprised four memory, four comprehension, and two application questions. These questions were selected from textbook exercises. The scores of the two comprehension tests were evaluated by a graduate student and a postdoctoral researcher who had majored in computer science. After measuring the scores of each student, they had a meeting to reach a consensus.

**Procedure**

The experiment was conducted in a usability laboratory and was divided into three phases: instructing, reading, and reviewing. All activities in the reading systems were logged in Microsoft Access database. In the instructing phrase, the entire experimental procedure was first explained to the participants. The participants were then instructed in the SQ3R reading strategy for 30 min. Finally, they were asked to read the practice material and use the assigned system without any time constraints.

For the reading phase, the participants were allowed 60 minutes to read through the experimental material and use the assigned reading system, after which, they were administered a reading comprehension test.

The reviewing phase was conducted two weeks after the reading phase. Participants were given 15 minutes to review the material while using their assigned system. All annotations were preserved in the systems. After fifteen minutes they received the paper handout and completed a comprehension test and navigational tasks.

**Result of the experiment**

*Reading behaviors during the SQ3R process*

The first analysis was used to examine how participants allocated time for each SQ3R step through descriptive statistics (Table 2). This allocation of time seems reasonable. However, except for the reading step, the standard deviations of these steps are large, which may indicate that time allocation for the steps differed significantly among the participants. Therefore, a cluster analysis of the time percentages spent in each of the five steps was conducted. This analysis classified the time allocation patterns into a homogeneous group. The K-mean method was used.
As shown in Table 3, four clusters were identified. The participants in Cluster 1 spent more time in the surveying and questioning steps, indicating them as slow SQ3R readers. However, because less time remained for the reciting and reviewing steps, they skipped these steps. By contrast, the participants in Cluster 2 demonstrated themselves as fast SQ3R readers who quickly completed the survey and question steps with more time remaining for the reciting and reviewing steps. The participants in Cluster 3 invested most of their time in the reading step and quickly passed the other steps, whereas the participants in Cluster 4 invested little time in the reading step.

Table 3. Summary table of K-means cluster analysis

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Survey</th>
<th>Question</th>
<th>Read</th>
<th>Recite</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1 (n = 15)</td>
<td>12.12%</td>
<td>5.57%</td>
<td>5.52%</td>
<td>6.64%</td>
<td></td>
</tr>
<tr>
<td>Cluster 2 (n = 9)</td>
<td>14.46%</td>
<td>8.15%</td>
<td>2.06%</td>
<td>28.99%</td>
<td></td>
</tr>
<tr>
<td>Cluster 3 (n = 12)</td>
<td>67.12%</td>
<td>57.12%</td>
<td>82.47%</td>
<td>27.45%</td>
<td></td>
</tr>
<tr>
<td>Cluster 4 (n = 5)</td>
<td>2.69%</td>
<td>21.98%</td>
<td>8.20%</td>
<td>20.13%</td>
<td></td>
</tr>
<tr>
<td>Survey</td>
<td>3.61%</td>
<td>7.18%</td>
<td>1.75%</td>
<td>16.79%</td>
<td></td>
</tr>
</tbody>
</table>

We conducted the second analysis to understand how participants create annotations in each step. Table 4 lists the number of annotations created in each step. The number of questions created in the questioning steps (Mean = 2.71) and notes created in the reciting steps (Mean = 0.54) was low. Twenty-four participants (8 using S1 and 16 using S2) did not pose any questions. Among the 24 participants, 16 students did not ask questions and did not visit any page in the questioning step; however, 8 participants visited certain pages without posing any questions. We concluded that the 16 participants were not motivated to pose questions. However, the eight participants may have been willing to ask questions, but did not know how to ask and, thus, browsed the materials searching for ideas. The same behaviors were also observed in the reciting step, in which 31 participants (14 using S1 and 17 using S2) did not create any notes. Among the 31 participants, 14 participants did not create any notes and did not visit any pages in the reciting step, and 17 participants browsed the material without creating any notes.

Table 4. Descriptive statistics of number of annotations created in each step

<table>
<thead>
<tr>
<th></th>
<th>Number of questions created in the question step</th>
<th>Number of comments created in the reading step</th>
<th>Number of recitations created in the reciting step</th>
</tr>
</thead>
<tbody>
<tr>
<td>All participants</td>
<td>Mean</td>
<td>2.71</td>
<td>3.37</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>4.61</td>
<td>4.53</td>
</tr>
</tbody>
</table>

Reading performance

An independent sample t-test was conducted to compare the comprehension scores of the two groups after reading. The results showed no significant effects of the reading systems on comprehension scores after reading between the S1 (Mean = 55.81, SD = 24.72) and S2 groups (Mean = 60.05, SD = 20.23; t = −.599, p = .552), indicating that the participants in both groups had the same reading performance.

Navigational performance

Navigational performance is evaluated using three variables: time spent, navigational path, and the number of tasks completed within two tries. The number of nodes a subject visited for completing the navigational tasks was counted as one navigational path.

Three independent sample t-tests were conducted to examine the effect of the reading systems on navigational performance. The results revealed a marginally significant effect of reading systems on time spent (t = −1.988, p = .054), indicating that the participants using S1 (Mean = 258.14, SD = 107.57) spent less time than did the participants using S2 (Mean = 323.55, SD = 102.86). Additionally, there was a significant effect of reading systems
on the number of tasks in which the information was found within two tries \( (t = -2.38, p = .022 < .05) \). The result indicated that the participants using S2 (Mean = 4.70, SD = 2.70) completed significantly more tasks within two tries than did the participants using S1 (Mean = 3.10, SD = 1.48). However, the navigational path was not significant \( (t = .726, p = .472) \).

| Table 5. Navigational performance between the systems with and without annotation map |
|--------------------------------|-------------------------------|-------------------------------|-----------------|------|
|                                | Without annotation map        | With annotation map           | \( t \)-statistic | df  |
| Time spent (second)            | Mean  | SD  | Mean  | SD  |                |
|                                | 258.14 | 107.57 | 323.55 | 102.86 | -1.988 | 39  |
| Navigational path              | 52.10  | 20.09  | 46.50  | 28.72  | 0.726  | 39  |
| Number of tasks completed within two tries | 3.10  | 1.48  | 4.70  | 2.70  | -2.38 * | 39  |

\* \( p \)-value < 0.05, ** \( p \)-value < .01

**Reviewing performance**

Because reading performance may affect reviewing performance, a one-way analysis of covariance (ANCOVA) was used to examine the effect of the comprehension scores of the two groups after reviewing. The covariate was their comprehension score after reading. A significant effect of the reading systems on comprehension scores after reviewing was found \( (F = 5.218, p = .028 < .05) \), indicating that the participants using S2 (Mean = 62.21, SD = 2.86) had significantly higher comprehension scores than did the participants using S1 (Mean = 53.08, SD = 2.79) after reviewing.

**Study two**

Study two involved administering a questionnaire and conducting an unstructured interview to collect the qualitative data for understanding student perceptions and levels of satisfaction regarding the use of such a system. All students from the S2 group in Study One were selected to participate in this study, which continued for two days. On the first day, the experimenters instructed the participants in how to use this e-book system. The participants then read a text consisting of 13 pages. Finally, the participants were administered an exam. On the second day, the participants read a text consisting of 16 pages. The participants then completed a questionnaire. Finally, the experimenters randomly selected three participants and interviewed them individually.

**Findings of study two**

| Table 6. Satisfaction questionnaire |
|----------------------------------|-------------------------------|-----------------|------|
| Items                            | Mean  | SD  |                  |
| Reading guidance can help me learn SQ3R efficiently. | 4.05  | 0.51 |
| I can understand what purpose each step has and how to perform each step. | 4.10  | 0.45 |
| I think the instructions are clear. | 4.20  | 0.41 |
| I have followed the instructions for each step to apply SQ3R. | 3.70  | 0.80 |
| I can demonstrate high reading performance if I follow the instructions. | 3.75  | 0.79 |
| The annotation map can help me to remember the structure of reading materials. | 4.55  | 0.51 |
| The annotation map can help me to recall the content of reading materials. | 4.30  | 0.66 |
| The annotation map can improve my reading performance. | 4.30  | 0.57 |
| The annotation map can help me to review the learning materials efficiently and effectively. | 4.20  | 0.77 |
| The annotation map can help me find a specific annotation easily. | 4.30  | 0.80 |
| The annotation map can help me find a specific paragraph easily. | 4.47  | 0.61 |
| I think that using the e-book system to read textbooks can enhance my reading performance. | 3.85  | 0.59 |
| I think that the e-book system is easy to learn and use. | 4.15  | 0.59 |

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Table 6 lists the questionnaire results. The value of Cronbach’s alpha for the 13 items was 0.84, indicating a highly acceptable level of reliability. The results showed that the participants had a positive attitude regarding our system. Additionally, we summarized several focal comments and suggestions proposed by the three participants in the unstructured interviews. The summary is listed as follows:

- The SQ3R strategy is cumbersome (n = 3).
- I am not used to asking questions about the section title before reading (n = 3).
- The number of words in the descriptions of the five SQ3R steps is too many. Although the descriptions are very clear, I suggest that the number of words be shortened (n = 3).
- I can remember the instructions for each step after my first reading. I believe that showing the descriptions is not necessary in subsequent reading (n = 3).
- I sometimes inadvertently view the annotation map while reading. The map distracted my attention (n = 1).
- Organizing annotations hierarchically is inconvenient. I must interrupt longer periods of reading when organizing annotations into the hierarchical structure (n = 3).
- When I review the reading materials, I first view the annotation map, then sequentially browse the materials in the e-book (n = 3).

**Discussion**

This study developed an e-book system to facilitate textbook reading through the SQ3R process. A quasi-experiment was designed to answer two questions. For Question 1, the descriptive statistics and clustering analyses revealed two problems. First, the time allocated among the participants showed a large difference. It shows that the participants had problems monitoring their reading process and allocating their time. Second, the readers were unwilling or did not have the ability to question and summarize textbook content. These results indicated that the current status of this reading guidance application does not effectively guide readers to complete the SQ3R process.

To overcome these problems, we offer several additional design suggestions. In this study, reading guidance provided novice learners with full control. However, findings from previous research suggest that providing novices with full control imposes too much of an extraneous load (Ayres & van Gog, 2009; Corbalan, Kester, & van Merrienboer, 2008). We suggest that this reading guidance module should increase system control to regulate novice learners before they can implement the SQ3R process independently. Second, solely providing instruction in how to conduct the SQ3R steps is insufficient; the system should provide effective scaffolds to support readers in performing highly cognitively demanding tasks (e.g., by explicitly asking readers to write crucial points or answer questions in the reciting step). Third, this system should support readers in monitoring and maintaining awareness of their reading progress, for example, by providing time management functions to raise awareness in novice readers of the time allocated and used.

Regarding Question 2, the participants did not significantly differ in comprehension scores after the reading phase. Based on student questionnaire results and comments, the annotation map supports readers in remembering the structure and content of textbooks. However, it also has several drawbacks that impede reading comprehension. First, the annotation map may draw readers’ attention away from reading. The distraction effect was also found in previous studies related to structure overview in hypertext reading (Hofman & Oostendorp, 1999). Second, interruptions in reading or attention shifts can impair learning and retention (DeStefano & LeFevre, 2007). Because users who employ the e-book reader system with the annotation map must additionally select a node they wish to highlight or comment on, the interrupted time for them is longer.

The results for reviewing performance revealed that participants using S2 had significantly higher comprehension scores than did participants using S1 after reviewing. This is because the annotation map reminds readers of what has been constructed and performed and helps them navigate between pages to glean crucial points quickly. Therefore, the participants with the annotation map in this study received higher comprehension scores when they had a limited time for review.

The S2 group completed significantly more tasks in two attempts, as compared to the S1 group. However, the S2 group spent a marginally significantly longer time to complete the tasks than did the S1 group. The navigational path
between both groups did not yield a significant difference. The following reasons might explain these results. First, within-text annotations are contextual cues associated with textbook content. The annotation map presenting an overview of the annotations helps readers recall the associations. If readers can correctly recall which annotation is associated with the target, then they can directly link to the target page with one click of a mouse on the annotation node. Therefore, S2 enhanced the performance of finding targets in two attempts. Second, when participants cannot clearly remember the location of the target, S1 users sequentially browse the pages through the links provided by the materials. By contrast, S2 users first scan the hierarchical structure to guess the nodes that may be associated with the target and then link to these pages associated with the nodes with one click. Because the S2 users in this study spent time thinking, they used more time than did the S1 users. Third, although the S1 users spent less time finding the targets, they still negotiated a longer navigational path. This may be because S1 users sequentially browse pages through the previous and next links provided by the materials. This navigational strategy allows quick switching between pages. Therefore, the length of the navigational path of the S1 users in this study was longer than S2, although it is not statistically significant. These results indicate that the annotation map supports students in accurately locating targets.

The results related to the annotation map show that the annotation map is helpful for reviewing and navigating activities. However, reading performance was not significantly improved. We believe that this may be due to the effects of distraction and interruption. To solve these problems, we suggest that teachers change the time for organizing annotations from during reading to after reading. Accordingly, students need only highlight text and add notes during their reading, and organize the annotations after the reading step. Thus, the two effects of distraction and interruption should disappear.

Several previous studies that have asked students to organize concept maps during reading have shown that concept maps can improve reading performance (Kwon & Cifuentes, 2009). However, these results are inconsistent with those of our study. An annotation map is a hierarchical concept map; the relationship between the nodes is top-down. The concept maps constructed in previous studies have been network structures, on the other hand, so the relationship between the nodes has been more complex. Regarding this complexity, students who construct network concept maps engage in a deeper encoding process than do students who construct hierarchical concept maps. Engaging in a deeper encoding process may result in higher reading performance. However, hierarchical concept maps are easily organized, and constructing network concept maps requires substantially more effort. Although constructing network concept maps may result in higher reading performance, the effort may also lower students’ motivation to use it. Determining which concept map is more feasible in practical classes should be investigated further.

The proposed e-book system was designed to support student reading during the SQ3R process. However, the approaches and strategies students use during their usual reading processes vary. SQ3R is not suitable for all students. We believe that SQ3R can benefit students who do not apply consistent reading strategies or do not demonstrate proficient reading skills. Therefore, teachers must determine students’ reading abilities and assign adaptive levels of system control for each student before introducing this strategy and system. For proficient readers, this system can provide the annotation tools and the annotation map. Students can read textbooks by using their usual reading processes and strategies without requiring reading guidance. For poor readers, teachers can assign the e-book system with reading guidance. When students have more experience in using the SQ3R strategy, teachers can reduce the level of system control. For example, teachers can cancel the instruction in each step when a student has used the system for once or twice, or cancel the questioning step when a student demonstrates the ability to ask questions in the questioning step. By applying this fading process, poor readers have the opportunity to become proficient readers.

Training students in reading strategies consumes considerable time and effort. In Taiwan, teachers do not have adequate time to accomplish this. Therefore, applying this system can solve this problem. Teachers can incorporate this system into a specific course learning activity, such as a homework assignment. Teachers can assign students reading based on their teaching progress. Students can then use the system to complete their reading assignments. Because the system is combined with a learning activity, students should have more motivation to use it. Thus, teachers would not require too much additional course time to instruct students. In addition, students (particularly Taiwanese college students, who lack regular reading habits and sometimes demonstrate low reading skills) can learn diverse reading strategies and regulate their reading effectively.
Conclusion

The proposed e-book system with the reading guidance module and annotation map was anticipated to support the SQ3R reading process for novice learners. An experiment revealed several findings and prompted suggestions. First, the annotation map is a hierarchical concept map that can improve reviewing and navigational performance, but not reading performance. Reading performance may be impeded by the effects of interruption and distraction. Second, the results of reading performance are inconsistent with those of previous studies, possibly because previous studies have used network concept maps, whereas the annotation map is a hierarchical concept map. This prompted two questions: (1) Do students prefer hierarchical or network concept maps? (2) Does organizing a network concept map after reading result in higher reading and reviewing performance than does organizing a hierarchical concept map after reading? In addition, SQ3R is not the usual way for students to read textbooks. When students have limited experience in SQ3R, they encounter difficulties in monitoring their reading progress and performing specific reading strategies that are highly cognitively demanding. This study determined that the types of reading guidance that provide only the static scaffolding of instructing, modeling, and cognitive structure is insufficient. We offer additional design suggestions consisting of offering more system control for novice learners and providing scaffolding tools to support readers in performing tasks that are cognitively demanding, as well as to monitor their reading progress. In the future, we will redesign the system based on the suggestions and will incorporate it in a practical course for a longer duration.

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References


