

A LEARNING RECOMMENDATION TO IMPROVE ELECTRONIC TEXTBOOK LEARNING EXPERIENCE

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ABSTRACT. *Technology Enhanced Learning (TEL) is one of the most dynamic areas of inquiry in education. One form of TELs, on-screen learning, has become the topic of interest to many works. It is popular mainly with young people despite all findings, which undoubtedly suggest that it is detrimental to learning. The method hinders learning experience due to the reading spatial instability, difficulties in establishing mental map, and reduced visual ergonomics. Currently, many textbooks are available in electronic form and a majority of the students in Bina Nusantara University in Indonesia, for example, consider the way to be more convenient and preferable. In the electronic form, the textbooks are much more affordable. They are more accessible than the printed books. This work intends to explore a method of improving the learning quality of the electronic textbooks. The improvement is expected to be achieved by enriching the electronic textbook with cues in the form of margin notes, highlights, markers, lines and arrows, and navigation tools provided by the subject matter expert. The method is evaluated on a small class of 18 students at the university, and its effects are assessed. The participants are divided into two groups having the same distribution of the past academic performance where one group is assigned to learn using the recommendation system, and the other is without the system. After the learning, their mentalities are assessed systematically by qualitative and quantitative methods. The participants with the recommendation system outperform those without it significantly, marked by the values of the Cohen's effect size d larger than 1.20 with the standard deviation about 0.563.*

Keywords: Learning recommendation systems, On-screen learning, Technology enhanced learning, Portable document format, E-learning

1. Introduction. This study is within the category of Technology Enhanced Learning (TEL). TEL has been recognized as one of the most dynamic areas of inquiry in education [1]. TEL aims to design, develop, and test socio-technical innovations that support and enhance learning practices [2]. Specifically, TEL is about recommender systems, designed to improve learning experiences. For example, [2] developed a recommender system to provide learners a list of relevant materials for a given course.

Many previous findings suggested that technology potentially enhances some aspects of learning experiences. Some suggested otherwise that technology might interfere. For instance, we consider the case of reading on the computer screen. From the perspective of cognitive processes, the case had been studied widely such as by [3, 4, 5, 6].

They concluded that reading on the computer screen had many drawbacks. First, the reading process often underwent spatial instability that occurs primarily during the screen rolling. The instability detrimentally affected the reader's mental representation of the material [3, 4, 5]. Second, according to [6], the reading process made the readers challenging to establish a mental map or a spatial layout of the text in entirety. On-screen

reading was better for the shallow reading of short texts, not for the effortful learning of textbooks [7]. Third, on-screen reading had a poor visual ergonomic where the screen refresh-rate, contrast level, and fluctuating light interfered with the cognitive process [8, 9].

This study is our first step to understand whether a recommender system can mitigate the detrimental effects of on-screen reading or not.

TEL has been studied from various context including in-class learning, self-regulated learning, and collaborative learning. [10] investigated the use of video game to support the teaching of Introductory Economics course and its effects on cognitive and affective aspects of the learners. [11] reported a systematic review on 19 studies regarding the effects of mobile devices/tablets on children learning and development. It concluded that the majority of studies reported positive effects on literacy development, mathematics, science, problem-solving, and self-efficacy.

In self-regulated learning, TEL provided more autonomy in learning and minimized dependency on lecturer [12]. TEL had also been used to enhance the implementations of the self-regulated learning principles: delayed meta-cognitive monitoring, content summarization, selection of review material, and practice tests [13, 14]. [15] concluded that the use of TEL, in the form of a digital Pedagogical Agent (PA), significantly improved the learning outcomes of fifth graders, who were carriers of a particular gene, the DRD4 seven-repeat allele, making them more susceptible to environmental influences. [16] suggested that technology-based subject expert can support individual students by communicating a range of processes and cognitive activities. Generally, TEL or educational computer, in particular, was identified to be well-suited for collaborative learning [17, 18, 19]. However, they might exhibit socio-emotional challenges due to member's backgrounds [20]. For children, [21] concluded that learning on digital media holds both challenges and promise. Young children sometimes find it difficult to learn from video and touchscreens. However, in the university setting, [22] concluded digital technologies were an integral aspect of the university student experience although they were clearly not transforming the nature of university teaching and learning.

This work intends to study to what extent a recommendation system may improve the learner cognition on on-screen learning for material that requires effort-full learning. [7] found the effort-full learning by on-screen reading was difficult.

This manuscript has the following structure. Section 2, Research Method, presents the research procedure, materials, a brief description of the measurement site, and the statistical analysis method. Section 3, Results and Discussion, presents the data of the students' performance, the statistical analysis results, and a brief discussion. Finally, Section 4, Conclusion, summarizes the research problems and its results.

We note that the initial findings of this research had been presented in EECSI 2017 Conference [23], and this study is a further extension.

2. Research Method. The following research procedure is performed to understand how a simple learning recommendation system improves the understanding of students.

Firstly, we select learning materials from a widely used textbook in Bina Nusantara University. The materials are Chapter 9 and Chapter 10 of the textbook of [24] and are available electronically in pdf format.

Secondly, we ask a subject matter expert to provide learning recommendations on the materials. The expert studies the materials and provides learning recommendations on the electronic documents by using highlights, marginal notes, annotations, hyperlinks, and interactive objects. The recommendations are designed to help students in the following respects: minimizing the need for the screen scrolling; helping students understanding the entire text organization; improving the visibility of essential keywords, sentences, and formulas; establishing connections between ideas; and strengthening important concepts.

The examples of the learning materials enriched with the learning recommendations are shown in Figure 1. Figure 1(a) shows a case of the learning outcome 2 of the chapter, which has nine learning outcomes in total. In this example, the subject matter expert considered the keywords “hypothesis testing”, “population mean”, and “z statistic” to be the most important aspects of the learning outcome. Thus, the expert highlights the three keywords. To the right of the passage, a button labeled “Detail LO2” is provided. The button will instantly take the students to the relevant part of the text. The object allows students to see the relevant material part with a minimum screen scrolling. Figure 1(b) shows another example of the learning recommendation. The context related to this figure is about the development of null and alternative hypotheses. The annotation “Example null and alternative hypotheses” is provided by the expert to help the students identify the passage content. In addition, the relevant passage is framed, and an arrow is added to point to the related implication of the expression of the passage.

2. Reach a statistical conclusion in hypothesis testing problems about a population mean with a known population standard deviation using the z statistic. Detail LO2

(a) This figure shows the learning outcome 2 of the session where the keywords were highlighted and an interactive object, the button, was provided to bring the learner to the relevant part within the material.

Example null and alternative hypotheses

wants to test to determine whether their packaging process is out of control as determined by the weight of the flour packages. The null hypothesis for this experiment is that the average weight of the flour packages is 40 ounces (no problem). The alternative hypothesis is that the average is not 40 ounces (process is out of control).

It is common symbolism to represent the null hypothesis as H_0 and the alternative hypothesis as H_a . The null and alternative hypotheses for the flour example can be restated using these symbols and μ for the population mean as:

The above statements are written this way. H_0 is normal condition; H_a is not normal.

$H_0: \mu = 40 \text{ oz.}$
 $H_a: \mu \neq 40 \text{ oz.}$

Normal condition (H_0)

(b) Another example of the provided learning recommendations: annotations, highlights, and graphical objects were provided to explain the materials.

Note in the market share example that the null hypothesis also contains the less than case (<) because between the two hypotheses (null and alternative), all possible outcomes must be included (<, >, and =). One could say that the null and alternative hypotheses are mutually exclusive (no overlap) and collectively exhaustive (all cases included). Thus, whenever a decision is made about which hypothesis is true, logically either one is true or the other but not both. Even though the company officials are not interested in “proving” that their market share is less than 18%, logically it should be included as a possibility. On the other hand, many researchers and statisticians leave out the “less than” (<) portion

(c) A highlighted passage within the learning material that is important for students to understand the concepts of null and alternative hypotheses

FIGURE 1. The examples of the learning recommendation to improve the student learning

The research participants are the third-year undergraduates of the School of Business Management of Bina Nusantara University in Jakarta, Indonesia. Those students enroll in a small special class so-called the global class. All are fluent in English. The university sets a certain level of English proficiency as a requirement for students to enroll in the global class. For this class type, all subjects are delivered in English and all teaching materials including textbooks, slides, assignments, and exams are also in English.

The number of participants is 18 students; 33% students are female, and the remains are male. They are about 20 years old; the age is not systematically assessed. All are Indonesia native, and English is their second language. The students in the class are separated into two groups, matched for their academic performance. Each group has nine students.

The teaching material is provided in laptop in pdf format. All students learn the material using Adobe Acrobat Reader. The students are provided a one-hour duration to learn the material. At the end, their understanding is assessed by a set of problems in multiple choices with the duration of 30 minutes. The assessment material is printed. The control group is assigned to learning materials without the learning recommendation. The treatment group is with the learning recommendation.

After learning the materials, the students are assessed for their knowledge acquisition and preference. The first aspect is evaluated quantitatively where the students are given some problems to solve. The second aspect is evaluated qualitatively via interviews. The typical quantitative assessment is reproduced in Table 1. The interview is performed individually to all participants. The questions asked are: “Do you agree that learning on screen is harder than learning on print?”, “Do you think the learning recommendation helping?”, and “How do you use the learning recommendation objects?” The last two questions were provided only to those who used the recommendation system. The participants’ responses are cross-checked to the other participants to determine its reliability. Finally, the student scores on the assessment are analyzed statistically using Mann-Whitney U test [25] and the Cohen’s d effect size index [26].

TABLE 1. The example of the quantitative assessments for student understanding

In an attempt to determine why customer service is important to managers in the United Kingdom, researchers surveyed managing directors of manufacturing plants in Scotland. One of the reasons proposed was that customer service is a means of retaining customers. On a scale from 1 to 5, with 1 being low and 5 being high, the survey respondents rated this reason more highly than any of the others, with a mean response of 4.30. Suppose the US researchers believe American manufacturing managers would not rate this reason as highly and conduct a hypothesis test to prove their theory. Alpha is set at .05. Data are gathered and the following results are obtained. Use these data and the eight steps of hypothesis testing to determine whether U.S. managers rate this reason significantly lower than the 4.30 mean ascertained in the United Kingdom. Assume from previous studies that the population standard deviation is 0.574. The sample data are:

3, 4, 5, 5, 4, 5, 5, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 5, 4, 4, 4, 3, 4, 4, 4, 3, 5, 4, 4, 5, 4, 4, 4, 5

How many tails should be used for the test on this case?

(a) 1-tail (b) 2-tail (c) Multi-tail (d) No tail

What is the value of the test statistic?

(a) 1.42 (b) -1.42 (c) 1.43 (d) -1.43

Would they be able to reject the null hypothesis?

(a) Yes (b) No

2.1. The detail of the learning materials. This subsection provides the details of the learning materials used in the study.

The utilized learning materials are Chapters 9 and 10 of the textbook of [24]. The textbook is widely used by the university. The title of Chapter 9 is “Statistical Inference: Hypothesis Testing for Single Populations” and Chapter 10 is “Statistical Inferences about Two Populations”. These materials are provided to the students in pdf.

Briefly, the teaching materials of Chapter 9 are about the Hypothesis Testing (HT) procedure for the cases involving statistics: the mean, the proportion, and the variance, of a population. It covers two HT approaches: using the critical value and using the p -value. Specifically, the chapter has the objectives to enable the students to: (1) develop both one- and two-tailed null and alternative hypotheses that can be tested in a business setting

by examining the rejection and non-rejection regions in light of Type I and Type II errors; (2) reach a statistical conclusion in hypothesis testing problems about a population mean with a known population standard deviation using a z statistic; (3) reach a statistical conclusion in hypothesis testing problems about a population mean with an unknown population standard deviation using the t -statistics; (4) reach a statistical conclusion in hypothesis testing problems about a population proportion using the z statistic; (5) reach a statistical conclusion in hypothesis testing problems about a population variance using the chi-square statistic; and finally, (6) solve possible Type II error when failing to reject the null hypothesis [24].

The teaching materials of Chapter 10 are also about HT but involve two populations. Similarly, it also covers the critical value and p -value approaches. The chapter has the objectives to enable the students to: (1) test hypotheses and develop confidence intervals about the difference in two means with known population variances using the z statistic; (2) test hypotheses and develop confidence intervals about the difference in two means of independent samples with unknown population variances using the t test; (3) test hypotheses and develop confidence intervals about the difference in two dependent populations; (4) test hypotheses and develop confidence intervals about the difference in two population proportions; and (5) test hypotheses about the difference in two population variances using the F distribution.

To achieve the above learning objectives, [24] enforced a standardized procedure called HTAB System of Testing Hypotheses. HTAB stands for Hypothesize, Test, Action, and Business. The HTAB procedure is reproduced in Figure 2. Step 1 in Task 1 of the procedure is to establish the null and alternative hypotheses. To accomplish this step, the student should realize the characteristics of the two hypotheses. Our subject matter expert understood this need; thus, he highlighted the most important and relevant passages within the text to help the students zeroing in on the issue (see Figure 1(c)).

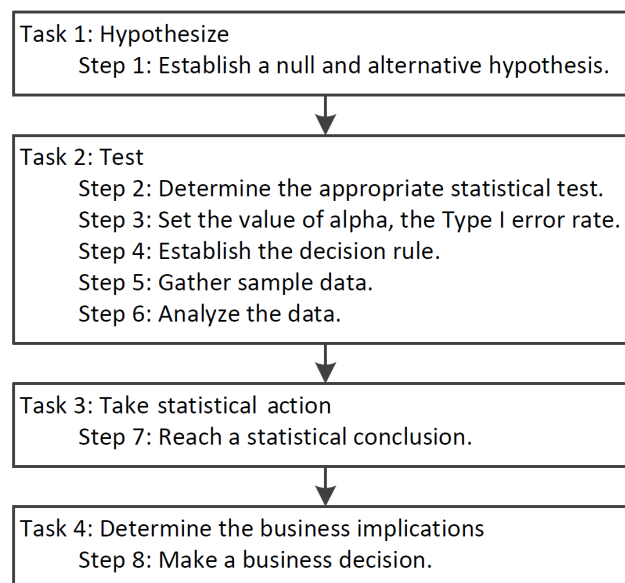


FIGURE 2. The HTAB System of Testing Hypotheses imparted by [24] to standardize the procedure

The second task consists of Step 2 to Step 6. To succeed with the task, the student should understand the probabilistic distribution of the statistic, the concepts of significance level α , the areas related to the null and alternative hypotheses within the curve, and how to compute the sample statistic. Our subject matter expert uses arrows and notes to demonstrate and connect these concepts (see Figure 3).

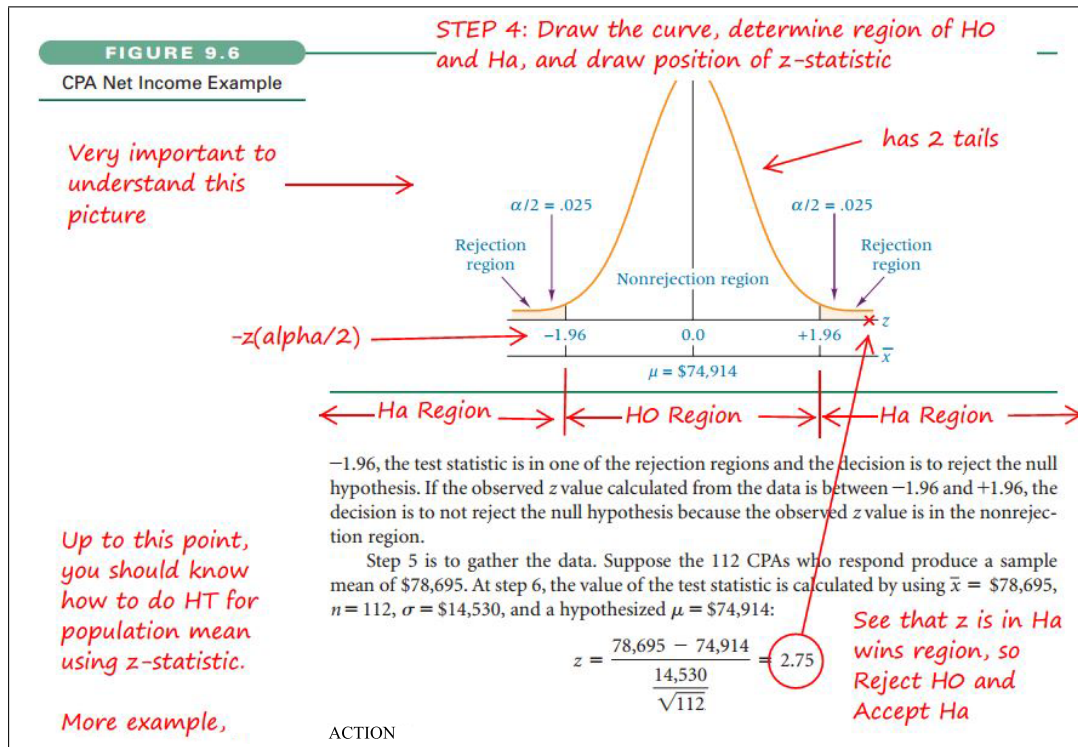


FIGURE 3. The subject matter expert uses arrows and notes to connect ideas and to enrich the learning material.

For example, he circles the sample statistic obtained from the sample, $z = 2.75$, and utilizes an arrow to point its location in the horizontal axis of the probability distribution curve. He has also divided the axis into three regions: two ‘Ha region’ and one ‘H0 region’. Besides the value of the sample statistic, he adds a note: “see that z is in Ha wins region, so reject H_0 and accept H_a .” This demonstrates how the subject matter expert uses arrows, notes, and picture to connect some ideas.

2.2. The detail of the measurement site. The data for this research are obtained in Bina Nusantara University in Jakarta, Indonesia. This section provides a brief description of the site.

Indonesia is a developing country located in the southeast of Asia. According to UNESCO, the nation has the literacy rate of 96.3% for male and 91.5% for female. Its education structure is 6-year primary school, 3-year middle school, 3-year high school, and tertiary and graduate education. The first three types are compulsory dictated by the nation law.

A large portion of the university-level textbooks is imported from Singapore. The price is unaffordable by most of the students. Moreover, the availability in the library is mostly limited. In the nation capital, only very limited textbooks are available on the stock of local stores. The number of stores is small. For those who are able to afford textbooks, and if the books are not in stock, they have to wait for weeks and even months. Those among others are reasons for students to prefer electronic textbooks.

Bina Nusantara University is one of the largest universities in the nation. It has a student body of about 20 000 students. Few departments may have up to 800 students enrolling per batch and they are divided into many classes.

A global class-type has been established since a few years back. To enroll in such a class, the students should meet the following requirements. They should obtain a high score on the entrance examination, a proficient level of English with a TOEFL score higher than 450, and an aspiration to develop a career in the international scale.

The university utilizes a learning management system called Binusmaya where one of its functions is to distribute learning materials such as lecture notes in pdf and slides in PowerPoint across the large student body.

3. Results and Discussion. The obtained student scores for the two given assessments are shown in Figure 4.

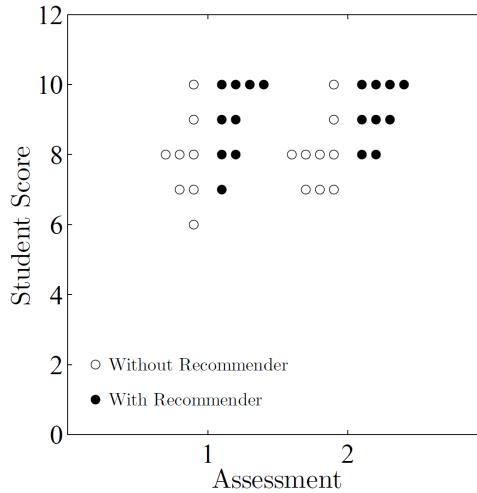


FIGURE 4. The distributions of the student scores for the two assessments. The learning materials were Chapter 9 and Chapter 10 of [24]. Assessment 1 was related to the learning material of Chapter 9 and Assessment 2 was about Chapter 10. The maximum possible score is ten.

Although the number of data is rather limited due to the difficulty of finding students having the acceptable level of language proficiency, the score distributions clearly show improvement of the student understanding of the learning material. Without the recommendation system, the score distribution tends to center around the score eight. The recommendation system shifts the center to the score ten.

The difference in the two population means are statistically evaluated using the Mann-Whitney U test and the Cohen’s d effect size index.

The results of the Mann-Whitney U tests are presented in Table 2. For the U -test, the p -values are 0.042 and 0.027, which are also lower than the significance level. For the effect size, the results are presented in Table 3 for the standardized mean difference Cohen’s d index and in Figure 5 for the associated forest plot. According to [27], the effect should be considered very large, if the d values are higher than 1.20. On this basis, we consider that the recommendation system has a significant impact to the student understanding.

From the interviews with the participants after the assessment, we derive the following notes. To all participants, learning the topic on the screen is hard. However, they do not consciously aware the factors that make it hard. The richness of the textbook makes it more difficult.

The provided learning recommendation has helped them in various ways. It helps them to understand that the material on each chapter can be broken down according to the learning outcomes. Each time, they are aware that they only need to concentrate on an outcome. Although the material is extensive, the learning recommendation helps them to focus only on the essential aspects. Thus, they skim and skip many parts of the material and spend more their time on the passages, which are marked important. They also utilize interactive objects to link concepts with formulas and examples. The participants perceive the provided annotations and highlights are essential to locate important sentences within the text such that they can easily bring their focus to those sentences. Furthermore, they

TABLE 2. The results of the Mann-Whitney U test for two population means – with and without recommender system – at the significance level $\alpha = 0.05$. A p -value lower than α denotes that there are significant differences between the two-population means under the condition set by the null hypothesis.

| | Assessment #1 | | Assessment #2 | |
|-----------------------------------------|---------------|--------|---------------|--------|
| | Without | With | Without | With |
| Mean | 5.76 | 9.00 | 8.00 | 9.20 |
| Variance | 2.28 | 1.25 | 1.00 | 0.69 |
| Welch's t-test | | | | |
| df | 15 | | 15 | |
| t Stat | -2.307 | | -2.817 | |
| p -value | 0.018 | | 0.007 | |
| t critical | -1.753 | | -1.753 | |
| Mann-Whitney U Test | | | | |
| Mean Rank | 12.000 | 7.000 | 12.220 | 6.780 |
| Sum of Ranks | 108.000 | 63.000 | 110.000 | 61.000 |
| Mann-Whitney U | 18.000 | | 16.000 | |
| p -value | 0.042 | | 0.027 | |

TABLE 3. The effect of the recommendation system on the student scores

| Study | Experimental | | | Control | | | Std. Mean Diff. Cohen's d (SD of d) |
|------------|--------------|-------|-------|---------|-------|-------|---------------------------------------------|
| | Mean | SD | Total | Mean | SD | Total | |
| Chapter 9 | 9.00 | 1.118 | 9 | 7.56 | 1.510 | 9 | 2.439 (0.610) |
| Chapter 10 | 9.20 | 0.831 | 9 | 8.00 | 1.000 | 9 | 1.305 (0.515) |

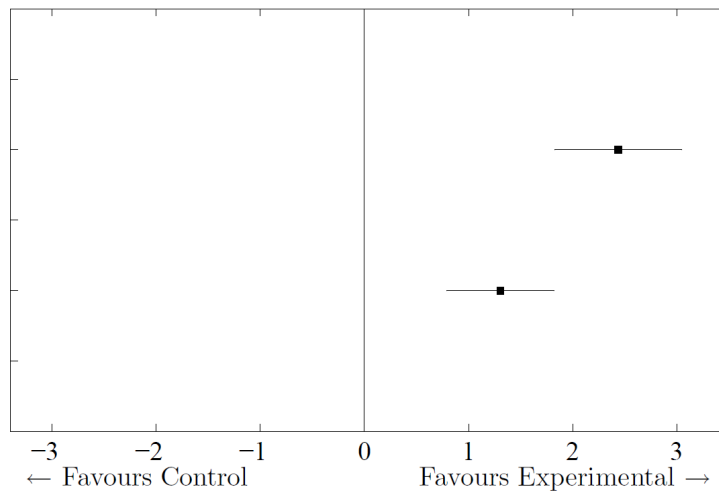


FIGURE 5. The forest plot of the impact of the recommendation system to the student scores

can repeatedly read the sentences to understand better. The provided interactive objects are beneficial to understand the text organization and to locate the essential concepts quickly.

Clearly, this early study has demonstrated that the learning recommendation system, in forms of annotations, highlights, and interactive objects, provided by the subject expert

are beneficial for learners. The object recommendations are used to highlight keywords and important concepts, to connect an idea with another, and to provide important comments that improve learner's understanding. We speculate that the current learning recommendation may be applicable, useful, and potentially has greater impacts in the context of the collaborative learning environment where each participant annotates and shares parts of the learning material he/she considers important.

4. Conclusion. On-screen reading has become a widely adopted reading modality with the proliferation of smartphones and tablet computers. The modality has been found to be not suitable for reading effortful materials such as textbooks. Reading on-screen has been found leading to spatial instability, difficulties in establishing mental map, and poor visual ergonomics due to the screen refresh-rate, contrast level, and fluctuating screen light. In this study, we evaluate to which extent a learning recommendation improves the quality of textbook learning on a computer screen. The learning recommendation is provided in terms of marginal notes, highlights, annotations, hyperlinks, and interactive objects. The learning recommendation is designed to help students achieving learning outcomes of the materials. The empirical data of the scores of the assessment tests demonstrate that those students who use the recommendation system outperform those without it by more than 1.2 of the Cohen's d effect size index. This suggests that the recommendation system has a significant impact on improving the student understanding.

As for the future work, we suggest investigating the idea of utilizing visual cues to increase on-screen learning thoroughly. For example, this can be achieved by using eye tracker instruments to directly record the data describing how the visual cues affect the interaction between the readers and the learning materials in-depth and rigorously.

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