Improvement of E-learning Quality by Means of a Recommendation System

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***Abstract*—Technology Enhanced Learning is one of the most dynamic areas of inquiry in education. One form of TELs, that is on-screen learning, has been well understood to hinder learning experience due to the reading spatial instability, difficulties in establishing mental map, and poor visual ergonomics. This work intends to study to which extend a learning a recommendation system improving on-screen learning experience. Participants were randomly divided into two groups: one group learning with the learning recommendation system and the other is without the system. Their understanding were assessed and a t-test was performed. The results indicated that the average score of learning with the recommendation system was significantly higher and the detrimental effects were mitigated.**

Keywords*—Learning recommendation systems, on-screen learning, technology enhanced learning, portable document format, e-learning

I. Introduction

This study is within the category of Technology Enhanced Learning (TEL), which 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 will support and enhance learning practices [2]. Specifically, TEL is about recommender systems that are designed to enhance learning experience. For instance, a recommender system with the main task of 'annotation in context' is designed to provide learners the list of relevant learning materials for a given course [2].

Many research findings suggest that technology potentially enhances some aspects of learning experiences. However, there are also findings that suggest otherwise, technology interferes certain aspects of learning experiences. For instance, let us consider the case of reading on a computer screen. Many aspects related to the reading on computer screen and its effects on cognitive process have been previously studied [3]–[6]. Some important and relevant findings are summarized the following.

Reading on computer screen has been found having a number of issues. The first issue is that the reading process often undergoes spatial instability that primarily occurs during screen scrolling. It detrimentally affects the reader's mental representation of learning material [3]–[5]. The second issue is that difficult for reader to establish mental map/spatial layout of text in entirety [6]. Some suggest that screen reading is better for shallow reading of short texts and not for effortful learning such as learning a textbook [7]. The third issue is that the screen reading has poor visual ergonomic where the screen refresh rate, contrast level, and fluctuating light interfere cognitive process [8], [9].

This study is our first step to understand whether the detrimental effects of the on-screen learning can be mitigated by using a recommender system.

TEL has been studied from various contexts including in class learning, self-regulated learning, and collaborative learning. Reference [10] studied the use of video game to support teaching of Introductory Economics course and its effects on cognitive and affective aspects of the learners. In self-regulated learning, TEL provided more autonomy in learning and minimized dependency on lecturer [11]. TEL has 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 [12], [13]. TEL in general and educational computer in particular were identified to be well-suited for collaborative learning [14]–[16] despite the fact that they may exhibit socio-emotional challenges due to member's backgrounds [17].

This work intends to study to what extent a system recommendation may improve the learner cognition on on-screen learning for material that requires effortful learning. Such material was identified difficult to be learned on-screen [7].

II. Research Methods

The participants were the 3rd-year undergradute students of the School of Business Management of Bina Nusantara University in Jakarta, Indonesia. Those students were in a small-special class, so called the Global class, where all of them were fluent in English. The university sets 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. All teaching materials including textbooks, slides, assignments, and exams are also in English.

The number of participants was 18 student; 33% students are female. They were about 20 years old; the age was not systematically assessed. All were Indonesian native and English was their second language.

The students in the class were separated into two groups with the following procedures. Firstly, the students were ordered according to their grade point averages from the highest to the lowest. The first student was assigned to Group A, the

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second to Group B, the third to Group B, the fourth to Group A, and so on. Each group had nine students. We assumed that this approach would results two student groups having equal academic performance.

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

The utilized teaching materials were Chapter 9: Statistical Inference: Hypothesis Testing for Single Populations and Chapter 10: Statistical Inferences about Two Populations from the textbook of Ref. [18]. These materials were provided to the students in pdf.

The learning recommendations on the pdf documents were provided by a relevant lecturer and by means of highlights, marginal notes, annotations, hyperlinks, and interactive objects. Examples of the learning materials enriched with the learning recommendations are shown in Figs. 1 and 2. The recommendations were provided to minimize screen scrolling, to help students understand entire text organization, to easily recognize essential keywords, sentences, and formulas, to easily identify connections between concepts, and to strengthen important concepts.

Figure 1 shows an example of the provided learning recommendation. It shows for the case of the learning outcome 2 of the chapter, which has nine learning outcomes in total. The subject matter expert considered the keywords: "hypothesis testing", "population mean", and "z statistic" to be the most important aspects of the learning outcome. To the right of the passage, a button labeled "Detail LO2" was provided. The button would instantly take the student to the relevant part of the text. It was designed such that the relevant part could be viewed with minimum screen scrolling.

Figure 2 shows another example of the learning recommendation. The context related to Example 2 is about the development of null and alternative hypotheses. The annotation "Example null and alternative hypotheses" was provided by the subject expert to help the student identifying the passage content. In addition, the relevant passage was boxed and an arrow was added to point to the related implication of the expression of the passage.

The student scores on the assessment were analyzed using t-test for two populations. We used subscript 1 to denote the case without the learning recommendation and subscript 2 to denote the case with the learning recommendation. Thus, the null and alternative hypotheses to be evaluated were: $\mathrm{H}_0 : \mu_1 \geq \mu_2$ and $\mathrm{H}_a : \mu_1 < \mu_2$. We evaluated whether the learning recommendation had effect or not to the student understanding. We expected that the provided learning recommendations would enhance student understanding.

The following statistic was used to evaluate whether the two-population means were significantly different or not. It was assumed that the population standard deviations were unknown. The significance level was set at 5%.

$$t = \frac{(\bar{x}_1 - \bar{x}_2) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \tag{1}$$

The degree of freedom is

$$\mathrm{df} = \frac{\left[\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right]^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}, \tag{2}$$

where n denotes the sample size, s is the sample standard deviation, $\bar{x}$ is the sample mean, and μ is the population mean.

III. Results and Discussion

The obtained student scores for the two given assessments are shown in Fig. 3. Although the number of data is rather limited due 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 tend 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 t-test. The results are presented in Table I. The tests are performed at the significance level α of 5%. Both assessments have the p-values of 0.018 and 0.007, which are significantly lower than the significance level. These results suggest that the learning recommendation significantly improves the student understanding. Its improves on average by about 17% and reduces the score variance by about 40%.

IV. Discussions and Implications

From the interviews with the participants after the assessment, we derived the following notes.

To all participants, learning the textbook on screen is really heard. However, they do not consciously aware the aspects that make it hard. The richness of the textbook makes it more difficult.

The provided learning recommendation has helped them in various ways. It helped them to understand that the material on each chapter could be broken down according to the learning outcomes. Each time, they were aware that they only needed to concentrate on an outcome. Although the material was

TABLE I. The results of the t-tests for two population means, with and without recommender system, at the significance level $\alpha = 0.05$. p-value lower than α denotes significant difference between the two population means under the condition set by the null hypothesis.

	Assessment 1		Assessment 2	
	Without	With	Without	With
Mean	7.56	9.00	8.00	9.20
Variance	2.28	1.25	1.00	0.69
df	15		15	
t Stat	-2.307		-2.817	
p-value	$+0.018$		$+0.007$	
t Critical	-1.753		-1.753	

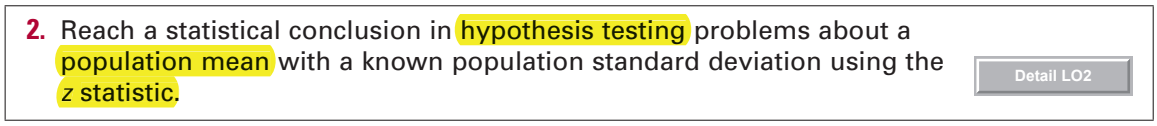

Fig. 1. The example of the learning recommendations provided by the lecturer on the electronic learning materials for the students. This figure shows the learning outcome 2 of the session. The keywords were highlighted and an interactive object, the button, was provided to bring the learner to the relevant part within the material.

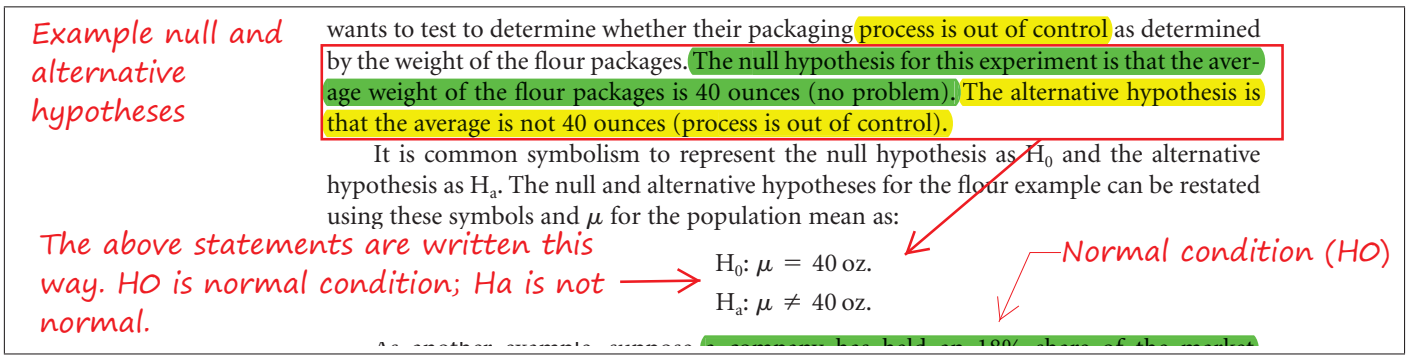

Fig. 2. Another example of the provided learning recommendations: annotations, highlights, and graphical objects were provided to explain the materials.

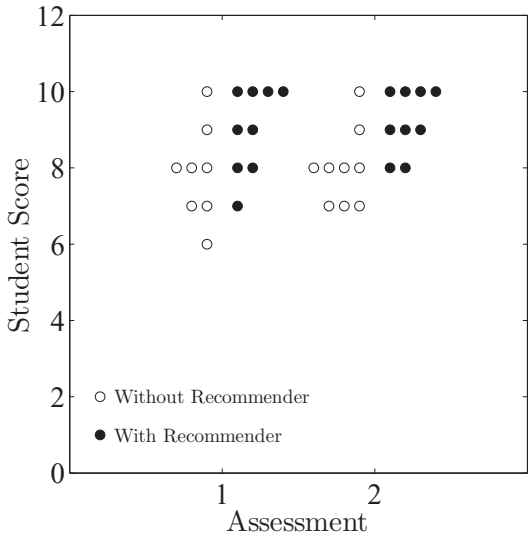

Fig. 3. The distributions of the student scores for the two assessments. The learning materials were Chapter 9 and Chapter 10 of Ref. [18]. Assessment 1 was related to the learning material of Chapter 9 and Assessment 2 was about Chapter 10. The maximum possible score is ten.

exhausted, the learning recommendation helped them to only focus on the most essential aspects. Thus, they skimmed and skipped many parts of the material and spent more their time on the passages, which were marked important. They also utilized interactive objects to link concepts with formulas and examples. The participants perceived the provided annotates and highlights were essential to locate important sentences within the text such that they could easily bring their focus to those sentences. Furthermore, they could repeatedly read the sentences to better understand them. The provided interactive objects were beneficial to understand the text organization and to quickly locate the essential concepts.

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.

V. Conclusions

Reading on-screen 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 to lead to spatial instability, difficulties to establish mental map, and poor visual ergonomics due to the screen fresh rate, contrast level, and fluctuating screen light. In this study, we evaluate to which extend a learning recommendation improving the quality of textbook learning on computer screen. The learning recommendation is provided in term of marginal notes, highlights, annotations, hyperlinks, and interactive objects. The learning recommendation is designed to help student achieving learning outcomes of the materials. The assessments of the student understanding suggest that the recommendation system is capable to increase the student score significantly. On average, it increases the score by about 17% on average and reduces the score variance by about 40%.

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