Comparing the Educational Effectiveness of eHealth to Deliver Health Knowledge between Higher Literacy Users and Lower Literacy Users

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Abstract—eHealth is undoubtedly emerging as a promising vehicle to provide information for individual self-care management. However, the accessing ability, reading strategies and navigating behavior between higher literacy users and lower literacy users are significantly different. Yet, ways to tailor audiences' health literacy and develop appropriate eHealth to feed their need become a big challenge. The purpose of this study is to compare the educational effectiveness of eHealth to deliver health knowledge between higher literacy users and lower literacy users, thus establishing useful design strategies of eHealth for users with different level of health literacy. The study was implemented in four stages, the first of which developed a website as the testing media to introduce health care knowledge relating to children's allergy. Secondly, a reliability and validity test was conducted to make sure that all of the questions in the questionnaire were good indicators. Thirdly, a pre-post knowledge test was conducted with 66 participants, 33 users with higher literacy and 33 users with lower literacy respectively. Finally, a usability evaluation survey was undertaken to explore the criteria used by users with different levels of health literacy to evaluate eHealth. The results demonstrated that the eHealth Intervention in both groups had a positive outcome. There was no significant difference between the effectiveness of eHealth intervention between users with higher literacy and users with lower literacy. However, the average mean of lower literacy group was marginally higher than the average mean of higher literacy group. The findings also showed that the criteria used to evaluate eHealth could be analyzed in terms of the quality of information, appearance, appeal and interaction, but the users with lower literacy have different evaluation criteria from those with higher literacy. This is an interdisciplinary research which proposes the sequential key steps that incorporate the planning, developing and accessing issues that need to be considered when designing eHealth for patients with varying degrees of health literacy.

Keywords—eHealth, health intervention, health literacy, usability evaluation.

I. INTRODUCTION

To date, people made use of medical or health websites to enhance their health knowledge, to reduce their anxiety about treatment, and to practice their disease-management skills, so as to reduce the number of times they need to see a doctor and the expense of medical treatment. However, lower literacy users took eight times longer than higher literacy users to complete an information search task, spent one-third more time on a web page than higher literacy users, visited eight times more web pages in total than higher literacy users in

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their search for the specific information they needed [1]. This begs the question of whether or not eHealth intervention has the same influence on the users with different level of health literacy.

There has only been sporadic research related to compare the difference between higher literacy users and lower literacy users in health communication during the past decade, such as the difference between the reading and navigational strategies of high literacy users and those with lower literacy skills [2], [3], the differences in information-seeking behavioral strategies between low and high literacy users [1], [4], and the need for different web interface designs for low and high literacy users [1], [5]. The ways to design effective eHealth intervention for diverse individuals with varying degrees of health literacy becomes a big challenge.

If users with different health literacy have different ways of learning and different preferences, then determining specific strategies, methodologies, and tolls to feed their diverse need will result in a better health communication. If the factors of design affect the educational effectiveness of health promotional media, then investigating the factors from various perspectives will result in a better design module. The purpose of this study is to compare the educational effectiveness of eHealth to deliver health knowledge between higher literacy users and lower literacy users, thus establishing useful design strategies for health providers to deliver care information which is sensitive to the needs of diverse individuals with varying degrees of health literacy. Several objectives have been met to achieve this aim, and these are listed below.

- To survey current methodologies and criteria used for assessing eHealth a success or failure
- To compare the educational effectiveness of eHealth to deliver health knowledge between users with higher literacy and users with lower literacy
- To explore the criteria used by users with different level of health literacy to evaluate eHealth

II. LITERATURE REVIEW

A. Health Literacy & Health Intervention

Health Literacy is defined in the report of American Medical Association Foundation, "Health literacy is the ability to use complex literacy skills in health-related circumstances and environments to help prevent, manage and treat health conditions" [6]. Another operational definition of health literacy "Health literacy is the degree to which individuals have the capacity to read and comprehend health-related print

material, identify and interpret information presented in graphical format (charts, graphs and tables), and perform arithmetic operations in order to make appropriate health and care decisions" [7].

Health intervention is defined as a series of actions with coherent goal, which is to achieve a change or produce identifiable results. These actions may include single strategic projects for a new policy or multi-component programs for regulatory initiatives [8]. To improve the use of healthcare services, improve health outcomes, decrease the cost of care, and reduce the disparity in the use of healthcare services and/ or health outcomes among different racial, ethnic, cultural, or age groups are the objectives of health intervention [9].

A plenty of patients navigate health information online to look for a second opinion or ask their physician new questions, which leads to new dialogue and improved shared decision-making between patients and physicians. Understanding patients' health literacy in relation to behavioral risk factors is an important goal in the prevention and detection of chronic diseases.

B. Higher Literacy Users VS. Lower Literacy Users

Skilled readers scan the relevant information quickly and resume the search task, whereas poor readers read word-for-word slowly and tend to give up searching in a short time. The differences between information-seeking behavioral strategies of lower literacy users and higher literacy users on on-line social service system are distinct [4]. Reading experience and navigating behavior of skilled readers and less skilled readers are in stark contrast when they adapt educational materials [3]. Table I is summarized to show the contrast between higher literacy users' skills in searching for information and lower literacy users' [3], [4].

TABLE I
HIGHER LITERACY (SKILLED) VS. LOWER LITERACY (LESS SKILLED)

	Higher literacy (Skilled)	Lower literacy (Less Skilled)
Reading	Can quickly scan most content to find essential ideas.	Read information word by word or skip over most content
Scan	Can scroll through content and navigate to next page	Find it difficult to scroll down content and easily lose visual concentration
Search words	Can enter search words accurately and make sense of search results	Find it difficult to spell and interpret search results.
Attention span	Attention span is sufficiently long to scan, scroll, and search content	Shorter attention span, leading to a quick decision to close the page.

C. Evaluation of eHealth Design

The main concerns of eHealth design include design of eHealth media, technical challenges in website design, environmental issue for eHealth researchers, and implementation of assessment methods [10]. According to Hsu & Chang [11], people use the following criteria to assess the quality of eHealth, "(1) Items of operating interface: layout design, clear links, visual identification, interactive process, easy to control, clearly presentation, fast feedback, user-friendly, repeat practice, search confusion; (2) Items of valuable results: useful information, whole concept, multi-

search path, easy interactive function, reduction of search time, decrease of articles with no demand, clear results, explanatory accompanying text, helps understanding, ease of learning new information."

In the views of Choi & Bakken [12], the technical factors in eHealth that affect the satisfaction of low-literate users are as follows "visibility of system status; match between system and the real world; user control and freedom, consistency and standards; help users recognize, diagnose, and recover from errors; error prevention; recognition rather than recall; flexibility and efficiency of use; aesthetic and minimalist design; and help and documentation." In addition, Hubley & Copeman [13] advocate that the following factors of usability design can help e-health audiences to learn best, "keep the layout of pages consistent with clear navigation between pages, use headings and links that are easily identifiable, provide alternatives to frames, avoid flickering, blinking and pop-ups, take care when presenting information in tables to ensure that they make sense when translated by a screen reader, design pages do the fonts can be enlarged easily by the user, keep used of illustrations to a minimum, avoid use of color as a way to emphasize text on page, when essential information is provided in PDF form, also provide an HTML version." What is achieved from the above will serve as a reference for evaluating successful healthcare media.

III. MATERIALS AND METHODS

The study was implemented in four stages, including the development of testing media, a reliability and validity test, a pre-post knowledge test, and a usability survey. Firstly, a usability testing website was developed to transfer the healthcare information relating to the causation, symptoms, treatment and prevention of children's allergies. All of the developing strategies were informed by the literature review. All of the design tasks in the testing media were integrated and converted using a combination of Adobe multimedia-development application systems.

Secondly, in order to make sure that all of the questions in the questionnaire were good indicators to measure the important variables in this study, a reliability and validity test was conducted. A 5-point Likert-type scale of response options ranging from strongly disagree to strongly agree was used to elicit relative endorsement of a particular statement. Then, the questions with higher scores, which indicated greater appropriateness, were retained, while the questions with lower scores, which indicated lower appropriateness, were discarded.

Thirdly, 33 users with higher literacy who are undergraduate students in Public Health and 33 users with lower literacy who only achieved primary education were enrolled. All of the groups were asked to fill out the knowledge testing questionnaire before and after the trial. Thus, this research could measure their comprehension of the presented healthcare media. Every participant had 20 minutes to fill in a pre-test questionnaire, 20 minutes to view the testing media, and 30 minutes to fill in a post-test

questionnaire. Participants could raise their hands to ask questions at any time when they were filling in the questionnaires and viewing the testing media.

Finally, a usability evaluation test was conducted with the same 66 participants after the post-test to explore the criteria used by them to assess eHealth. Each participant was asked to complete a questionnaire to evaluate the usability of the testing media after the post-test. This consisted of 28 items of evaluation criteria, including the quality of information, appearance, appeal and interaction of the media in question. A five-point Likert Scale was used for every question, with higher scores indicating the higher appropriateness. The rating scale for measuring the appropriateness of the questionnaire was scored from 1 = very unimportant, 2 = unimportant, 3 = neutral, 4 = important, 5 = very important.

In view of the use of probability sampling, after discarding some inappropriate 6 samples, 60 valid samples remained. All the data retrieved from the questionnaires were checked and coded into a computer, and descriptive and inference statistics were applied to analyze the distribution using SPSS for Windows version 20. Some statistical data analyses were conducted, including a pair t-test adopted to test the differences between pre-test and post-test knowledge within each intervention group. An independent sample t-test was adopted to examine whether there were significant differences of the educational effectiveness between higher literacy users and lower literacy users. Descriptive Frequencies and Multiple Crosstabs were employed to explore the criteria used by users with different level of health literacy to evaluate eHealth. The methods used to analyze the data and results of the analyses are described in detail below.

IV. RESULTS

A. Data Analysis of Pre-and-Post Knowledge Testing

In order to examine whether there were significant differences between the results shown in the pre-test and the post-test within higher literacy group, a pair t-test was applied. Table II shows the results. The findings show that there were significant differences between the pre-test and post-test (t-value = 10.298, p < .001). Since the average right answers for measuring the performance of the post-knowledge testing in higher literacy group was around 26, which was between 21 and 28 right answers, this means the performance of the participant in higher health literacy group is excellent (1-7 = bad, 8-14 = ok, 15-21 = good, 21-28 = excellent, Items = 28).

TABLE II
PAIRED T-TEST (HIGHER LITERACY GROUP)

	Mean	Mean Difference	t-value
Pre-test	23.29	3.10	-10.298***
Post-test	26.39		

In order to examine whether there were significant differences between the results shown in the pre-test and the post-test within lower literacy group, a pair t-test was applied. Table III shows the results. There were significant differences between the pre-test and post-test (t-value = 9.063, p < .001).

Since the average right answers for measuring the performance of the post-knowledge testing in website group was 23, which was between 21 and 28 right answers, this means the performance of the participant in higher literacy group is also excellent (1-7 = bad, 8-14 = ok, 15-21 = good, 21-28 = excellent, Items = 28).

TABLE III
PAIRED T-TEST (LOWER LITERACY GROUP)

	Mean	Mean Difference	t-value
Pre-test	19.25	4.04	-9.063***
Post-test	23.29		

In order to examine whether there were significant differences of the influence of eHealth intervention between users with literacy and users with lower literacy users, an independent sample t-test was applied. Table IV shows the results. There was no significant difference between the effectiveness of health intervention between higher literacy users and lower literacy users (t-value = .147, p > .05). However, the average mean of lower literacy group was marginally higher than the average mean of higher literacy group.

TABLE IV
INDEPENDENT SAMPLE T-TEST (EDUCATIONAL EFFECTIVENESS)

Group	N	Mean	Std Deviation	Sig	t-value
Higher literacy	30	3.10	1.49	.884	.147
Lower literacy	30	4.04	1.89		

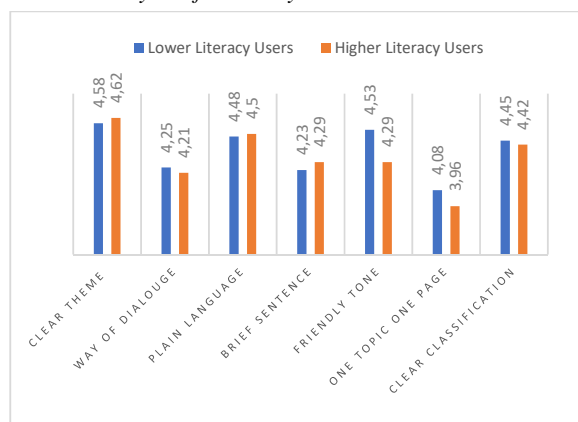### B. Data Analysis of Usability Evaluation

Fig. 1 Information Qualities (Lower literacy VS. Higher Literacy)

In order to examine whether users with lower literacy have different evaluation criteria from those with higher literacy when evaluating the eHealth, Multiple Response/Crosstabs test was used. Figs. 1-4 show the results: Briefly, the average score of those with a lower level of education was 4.22 and the average score of those with a higher educational level was 4.21, which indicated that all the evaluation criteria were agreed by both groups. However, the users with a lower level of education used different evaluation criteria than those with a higher educational level when evaluating the media of health promotion. For example, in terms of the quality of

information, the criterion of "friendly tone" obtained a significantly different score from the two groups, as did the criterion of "real photo" in respect of the appearance of content, the criterion of "government publication" related to the quality of appeal and the criterion of "video narration" related to the quality of interaction.
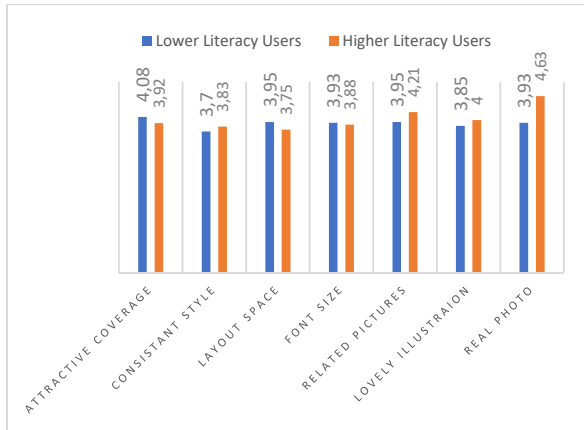

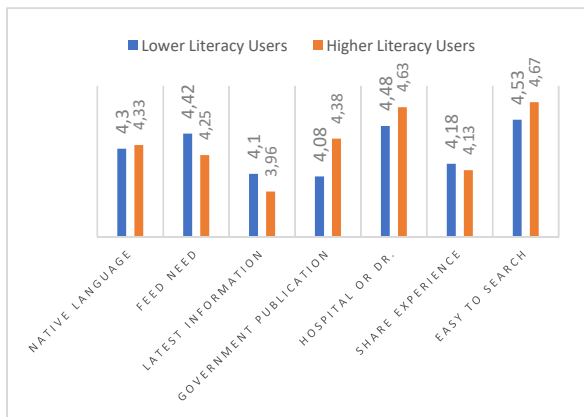Fig. 2 Appearance Qualities (Lower Literacy VS. Higher Literacy)

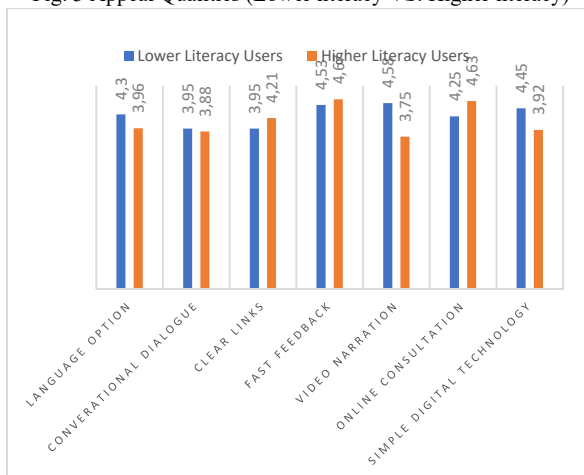Fig. 3 Appeal Qualities (Lower literacy VS. Higher literacy)

Fig. 4 Interaction Qualities (Lower literacy VS. Higher Literacy)

V. DISCUSSION AND CONCLUSION

Previous research has suggested that lower literacy users always possess a lower level of reading comprehension and employ weaker information-seeking strategies than their higher literacy counterparts [14]. However, it was surprising to find that lower literacy users performed significantly better than higher literacy ones, which suggests that this testing media had been well-designed for lower literacy users and well-accepted by them. It is also probably because the users with higher literacy are not as compliant as the users with lower literacy to receive any advice from healthcare media. According to past studies, the lack of opportunity and the digital-divide prevents low-literate users from accessing healthcare media [15], [16]. However, it was surprising to find that users in the lower literacy group who were not familiar with web-surfing performed marginally better than those who were good at it, which suggests that eHealth could become a more effective educational platform for the low-literate users if they had been developed well to meet target audience's need. This could also have resulted because the less experienced web users were more direct in their approach to and use of information.

The aim of usability testing is to identify and eliminate barriers to easy, safe and efficient use by target users, and to establish user acceptability and satisfaction with the intervention. As for the information design, some of the participants in the lower literacy group apparently lacked patience to read the text content but depended on the illustrations and photographs to understand the healthcare information. Some of them even skipped reading the text on content but directly watched the video-clip and listened to the voice-over. On the other hand, some of the participants in the higher literacy group indicated that the speed of video narration was so slow and disturbed their reading process, and that's why they liked to read the text content directly. As for the appearance design, the participants with higher literacy indicated that they preferred real photos rather than simple drawings to illustrate healthcare concepts, whereas the participants with lower literacy stated that they loved cute illustrations rather than serious medical photo to introduce healthcare knowledge. As for the appeal, the participants with higher literacy indicated that the content on website should clearly note the author's name, author's professional title, and author's service organization and publication date or recently modified date to prove that they are current and up-to-date, whereas the participants with lower literacy stated that the information provided on the website should meet their personal needs and concise for reading and understanding. As for the interaction design, the participants with higher literacy indicated that the style of subject, color and background should be designed consistently on the same page and the website should download quickly and recover efficiently, whereas the participants with lower literacy stated that the classification of the content of the website should be easy to search and the selection buttons should be clearly designed and aligned.

This research has two major limitations, one of which is the use of small probability sampling, while the other is the literacy level of participants. It was difficult to recruit participants because of the long duration of testing, while some feedback from the questionnaire may have been distorted because of literacy issues. Any small change in the data may have influenced the results because of the small sample size. Thus, it is important to analyze and validate a larger sample size. Future studies need to recruit a larger sample size and incorporate solutions to literacy issues in order to effectively optimize health intervention.

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