Effect of Document Enrichment on E-Learning

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Abstract: *In order to realize the idea of document enrichment we developed a tool called TermPedia which predicts and defines technical terms. The definitions are extracted from Wikipedia, and the technical terms are also linked to contextually relevant Wikipedia articles which provide further explanation for the definitions. This paper presents results from a user study that was carried out to find out the effect of document enrichment on e-learning from educational documents (textbooks). In particular the study tried to answer the following questions, 1. Does document enrichment improve understanding of an e-content? 2. Does document enrichment reduce the time needed to e-Learn from an educational document?*

I. INTRODUCTION

Many education institutions are in support of the propitious developments in information and communication technology (ICT) for enhancing e-learning. For example, the Higher Education Funding Council for England (HEFCE), published a report which notes that:

> "Much has been promised about the potential of [ICT] technology to revolutionise learning, with benefits identified in the dimension of extended opportunities," (JISC, 2004) among others.

These extended opportunities encompass the possibility that e-content can improve and broaden classroom-based learning. This research aims at the potential of ICT in improving and broadening students learning by providing easy access to e-content.

E-content like print-content may include terms and jargon that are unfamiliar to a student and we believe that such could hinder the process of learning if they are introduced in text without definitions or explanations. Moreover, in some cases, the definitions of technical terms may themselves contain difficult words that are not familiar to the student. In such cases, reading may become tedious and learning uncertain. Retrieving the definition of difficult words from sources outside the reading material is time consuming and could turn out to be distracting. For these reasons we provide easy access to the definition and explanation of difficult terms that occur in e-content, which process we refer to as document enrichment. On a broader scale, document enrichment can be defined as the process of automatically providing easy access to extra contextually relevant information for existing e-documents. This process is useful since writers normally posses some background knowledge, and readers vary, often unpredictably, in their level of background knowledge. For example, a reader who is not familiar with the field of Software Engineering, may find a term such as `mixin` difficult to understand. Our idea of document enrichment was realized by developing TermPedia, a tool which uses human language technologies (HLT) to predict and define technical terms. The term definitions are extracted from Wikipedia, and the predicted technical terms are also linked to contextually relevant Wikipedia articles which provide further explanation for the definitions. (Olango *et al.*, 2009) describes the technical details of document enrichment using TermPedia.

We hoped that if TermPedia was integrated into e-content, definitions and explanations of difficult terms would become easily available to students and e-learning would be improved. In addition, we believed that TermPedia would reduce the time necessary for e-learning if e-content is enriched with relevant information. Learning time would be reduced because the students would not have to navigate away from the e-content in order to retrieve difficult term definitions, explanations, or cross-references in a printed document such as a dictionary or glossary. In order to investigate the effect of document enrichment on e-learning with these aspirations, we integrated TermPedia into the e-content of a course at a University in a developing country. We then used the students' performance to provide an indication for the effect of document enrichment on e-learning.

The rest of this paper is written as follow: section II. discusses the importance of e-content in developing countries, section III. presents the methods used in studying the effect of document enrichment on e-learning and analysis of results from the applied methods. Finally section IV. provides a general conclusion on the indication of how document enrichment affects e-learning in relation to the findings presented in section III.

II. E-content in a Developing Country

WordNet, an on-line lexical database for the English language defines a developing country as:

> "a country that is poor and whose citizens are mostly agricultural workers but that wants to become more advanced socially and economically" (WordNet, 2012).

Learning through education is a basic way through which a developing country can make this kind of advancement. Since TermPedia focuses on improving e-learning, we believe that this tool shall be of help in the course of development for a developing country.

For example, e-content plays an importance role in providing access to course material in addition to improving and broadening classroom-based learning. This aspect of e-learning is necessary in a developing country because course materials are generally too expensive for students in such a country to afford, recalling that average families earn $1.25 a day (Ravallion *et al.*, 2008). As a result of poverty, the ratio of student to education material is very low at most universities in a developing country. For instance in Uganda only Makerere University had an acceptable ratio of students to education materials of 1:21 in 2010 (Olango and Bouma, 2011). This ratio was attained by the availability of ICT facilities at the University which provided the access of course material through e-content for students. Other universities in Uganda also have access to ICT facilities but on smaller scales compared to that of Makerere University. To illustrate, Gulu University a University in the North of Uganda also provides access to e-content for students in an effort to reduce the cost of buying course textbooks and other materials necessary for their learning and instruction. Unfortunately most of the students at Gulu University do not have ready access to this e-content because of the low ratio of students to computers which is approximately 40 students to 1 computer. Regardless of the low students to computer ratio at Gulu University, e-content provides students with an opportunity for e-learning through the access of various course contents at any place and time of convenience.

Moreover it is important to understand that e-learning is fundamentally about learning and not about technology (JISC, 2004). Therefore the benefits of enhancing e-learning have to be tested based on whether it facilitates learning and not technically. Accordingly this paper concentrates on the possibility of improving the process of learning through enriching students e-content. The effects of enriching students e-content was then investigated by carrying out a user study at Gulu University in Uganda. A screen shot of the user interface that displayed the enriched e-content by using TermPedia is shown in Fig. 1. The figure gives an example of a predicted term, `Software developer` in the context of Software Engineering with its definition in a pop-up window. Like this term, all predicted terms are underlined and hypertext. If a student moves a mouse pointer over any of the predicted terms, its definitions shows in a pop-up window. A student can also link to a Wikipedia article by clicking on the predicted term for further explanation in case the term definition does not provide adequate information for understanding the meaning of the term in context. The user interface provides an avenue for a student to learn easily by reading course materials that have been enriched by TermPedia.
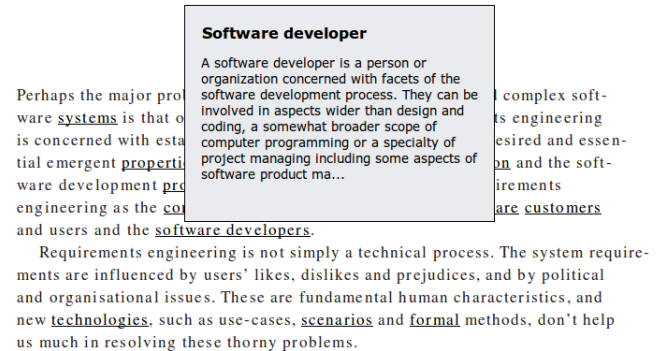

Figure 1: Snap shot of TermPedia user interface

III. USER STUDY METHODS

Gulu University is a very young public University which was established by the Government of Uganda in the year 2002 with a student population of 289[1] which has expanded to more than 4000 students as of today. The University currently has five faculties among which is the Faculty of Science. In turn this faculty has a number of departments including the department of Computer Science which has a total of more than 400 students. An assigned course reading for a specific category of students from the department of Computer Science was enriched using TermPedia. Please see section I. for a brief explanation on document enrichment and TermPedia. The performance of these students was then measured and analyzed in relation to TermPedia. The analysis provided a measurable indication of the tools usefulness with reference to the research questions in the abstract of this paper. These questions arose from an overall hypothesis that document enrichment is useful to students in higher education institutions, and the specific hypotheses guiding the study were as follows:

1. Document enrichment can improve understanding of e-content by providing contextually relevant information.

2. The time needed in e-learning can be reduced through the use of document enrichment.

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[1]http://www.enteruganda.com/brochures/uniguidegulu.html, cited on 1st. March, 2010

Answers to the research questions and resolutions about the tested hypotheses are discussed in subsection B.3. where data collected from the user study was statistically analysed.

A. Proposed Category of Students for the User Study

The Department of Computer Science offers a variety of courses, among which are Bachelor of Science in Computer Science (B.Sc.CS), and Bachelor of Information Technology (BIT). B.Sc.CS enables students to study theories and methods of processing information using computers, the design and operation of computer hardware and software, and the application of computer technology to all fields of knowledge. Similarly, BIT enables students to understand the systems used in digital data handling and retrieval. The course also provides an opportunity for students to develop skills in the techniques necessary to devise, develop and maintain these systems. The objective of BIT is to teach skills applicable to the safe storage of significant amounts of data, easy data modification, and cost effective information retrieval. It can therefore be said that both courses have a common interest in developing students who are able to understand and apply the underlying principles of Computer Science and Information Technology to processing information.

TermPedia is a document enrichment tool that applies underlying principles of Information Technology to solving some pedagogy problems in e-learning and knowledge retention. For this reason the TermPedia user study was carried out in the context of third-year B.Sc.CS and BIT students of Gulu University in their first semester 2012/2013. We felt that these students would be motivated to use the experimental software seriously. These courses consist of students who studied during the day (8:00 a.m. to 5:00 p.m., Monday to Friday) and on weekend (7:00 a.m. to 8:00 p.m., Saturday and Sunday). The user study only involved students following the day programme because they had a relatively relaxed timetable compared to the weekend students. It was assumed that the day students would have ample time to acclimate to the TermPedia user interface and provide reliable results for the study evaluation.

B. Collection and Analysis of Data

The category of students selected for this user study followed a Software Engineering course and their primary reading material was a book titled *Software Engineering* (Sommerville, 2001). Both hard and digital copies of lecture slides from this course material were given to the students at the beginning of the semester. It is assumed that the students diligently read the lecture notes in one of the two forms after which they underwent a number of tests according to chapters that had been already presented by their lecturer in class. The test results were used as evaluation data

for TermPedia. This data was collected before and after the students were introduced to TermPedia in order to gauge the students learning.

B.1. Collection and Analysis of Data by Closed-Book Test

Before the students were introduced to TermPedia, they were given a "closed-book" test to find out their level of competence. By closed-book we mean that students were not allowed to reference any textbook, notes, or other knowledge sources while answering the test questions. The test was given on specific sections of the Software Engineering book that the students studied during their course. This test had several questions with multiple choice answers. After the students had been tested, their results were randomly selected for analysis. The random selection of results was done prior to post filtering in order to remove incomplete test results and results from students who did not attempt to answer any test questions. The procedure was taken from Csomai and Mihalcea, (2007) who carried out a similar user study evaluation. That study enriched (or wikified) questions from a quiz for an on-line history course. On the contrary, the TermPedia user study enriches on-line reading material for an off-line course. A summary of the performance of the students after the closed-book test is shown in table 1.

	Group A	Group B
Number of students	15	15
Median	15	15
Mean	15.33	15.27
Standard deviation	00.62	00.46

Table 1: Summary of students closed-book test scores before they used TermPedia

Students results were divided into two groups A and B during the random selection. The summary of these results show that the students from these two groups were at the same level of competence. Both groups had a mean score of 15.3 and small standard deviations of 0.478 and 0.617 which shows that the general distribution of students scores does not deviate from the mean. The fact that the students were at the same level of competence gave a clear opportunity to perceive the change in their performance after they had been introduced to TermPedia. When the students had used TermPedia group A were given an "open-book" test with the help of TermPedia, while group B answered the same test without the help of TermPedia but also with the help of printed or written lecture notes. The procedure and results of the open book test are discussed in subsections B.2. and B.3. respectively.

B.2. Data Collected by Open-Book Test

After TermPedia was introduced to the students they were asked to read an electronic copy of chapter six from the Software Engineering book, which was the

	TermPedia Used (A)			TermPedia Not Used (B)		
	Time (Mins.)	Scores	%Scores	Time (Mins.)	Scores	%Scores
Median	48.00	16.00	80.00	43.00	15.0	75.0
Mean	46.87	16.33	81.67	43.87	14.80	74.00
sd(s)	03.98	02.23	11.13	05.46	03.21	16.06

Table 2: Summary of students open-book test scores after using TermPedia

only chapter available with full text in soft copy. This chapter was loaded onto the TermPedia user interface for the automatic prediction of technical terms. TermPedia also gave definitions of the predicted terms, these definitions where extracted from the first paragraph of Wikipedia articles that are relevant to the term in question. The predicted terms created hypertext links to Wikipedia articles for additional information. The students read this chapter for a total of eight hours during four sequential lectures in two weeks. After using TermPedia to read chapter six of their course material, they were given an open-book test. By open-book we mean that students were able to consult their course material, notes, and other relevant information during the test session. The test was open-book in the hope that the test results would reveal the efficiency of TermPedia through students' scores and time required to complete the test. The open-book test consisted of five questions and each question had two parts; (a), and (b). These questions required short answers where the (a) part of each question was a definition question. Question 1 from the test is given below for illustrative purposes.

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Qu. 1(a): What is mean time to failure?
Qu. 1(b): What nonfunctional requirement
          of a system does it measure?
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Before the open-book test, students were divided into the same two equal groups of 15 as in section B.1. Group (A) students were allowed to consult their course material only through the TermPedia user interface. Group (B) students could consult any of their reading materials in both hard and digital forms, but they had no access to the TermPedia user interface. Note that the control group B could search electronically in their digital material. We believe therefore that the test rather strenuously measures the added value of the document enrichment process. If group A performed better than group B, a conclusion could be made that TermPedia improves the process of e-learning by providing relevant contextual information. One might also conclude that TermPedia reduces the time required for e-learning if students in group A completed the test earlier than students in group B. Results from the open-book test are shown in table 2.

B.3. Analysis of Data Collected by Open-Book Test

Samples of data collected from the open-book test were investigated through box plots, and quantile-quantile

(Q-Q) plots. The Q-Q plots were examined to test if the samples have a normal distribution in which case we could then use a t-test for independent samples to investigate the differences in the means of the data. The data consisted of test scores, and the time the students used to complete the open-book test. We hypothesized that the mean score for students who used TermPedia during the open-book test would be significantly higher that the mean score for students who did not use TermPedia during the test. This would show improved performance with the help of TermPedia during the test and therefore an improvement in the process of e-learning. We also hypothesized that the mean time spent by the students to complete the test would be significantly smaller than the mean time for students who did not use TermPedia during the test. This would act as an indication that TermPedia shortens the time for finding relevant information. Detailed discussion of the findings from the collected data are given below with respect to both test scores and time spent by the students to complete the open-book test.
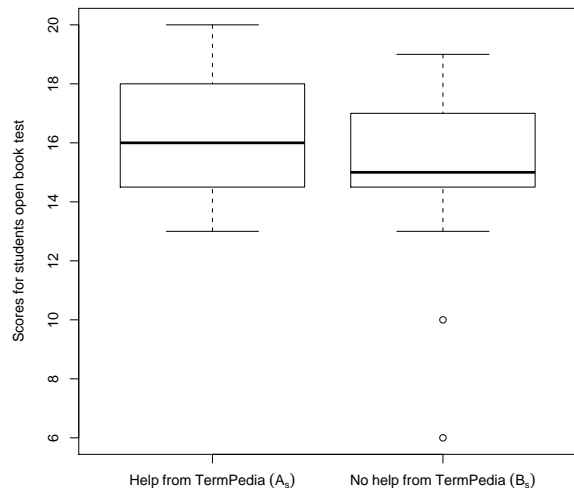

Figure 2: Box plot for open-book test scores of students

B.4. Analysis of Students Scores from Open-Book Test

Figure 2 displays two box plots that visualize the open-book test scores for students who consulted the course

material on TermPedia user interface (A_s) and students who consulted course material from sources not loaded onto TermPedia user interface (B_s). The box plots clearly show that sample distributions of A_s and B_s are similar since their inter-quartile ranges overlap. Although this is true, sample A_s has a greater central tendency compared to B_s because the median of A_s is closer to the center of it's inter-quartile range, revealing a distribution that is neither sparse nor skewed. A_s box plot also has no outliers, which shows that the data sample is likely to follow a normal population distribution. The median of the box plot for sample data B_s is below the center of it's inter-quartile range indicating that the sample may be skewed to the left. The skewness of sample B_s is further affected by outliers. Since both sample distributions are not wildly scattered, a Q-Q plot was used to check that sample B_s fits to a normal distribution. Figure 3 shows that this sample does not fit a normal distribution because the data points do not follow a straight line in the Q-Q plot.
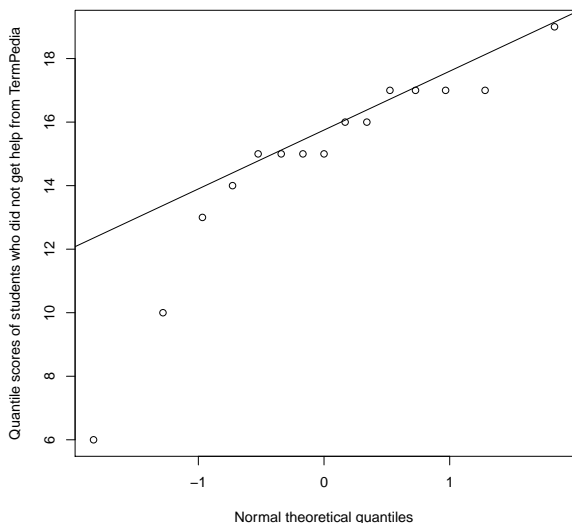

Figure 3: Normal Q-Q plot of open book-test scores for students in the control group B who were not helped by TermPedia

A ShapiroWilk test for data (B_s) from students who were not helped by TermPedia during the open-book test gives a p-value of 0.01 which indicated that there is significant evidence to show that B_s data did not come from a normally distributed population. With one normally distributed sample A_s and one skewed sample B_s, we carried out a Mann-Whitney-Wilcoxon (MWW) test to see if scores from A_s were significantly higher than scores from B_s. The MWW test gave a $p-value = 0.12$ indicating that there was insufficiency evidence to show that students who got help from TermPedia during the open-book test performed better than the students who did not get help from

TermPedia during the same test.

However, when we ignored one of the outliers in B_s and subjected the sample to another Shapiro-Wilk test, we obtained a p value$= 0.184 > 0.05$. This p-value showed that the rest of B_s comes from a normally distribution population. With the outliers ignored, we could therefore assume that both population samples A_s and B_s tend to a normal distribution. A t-test for independent samples was then used to investigate if the mean score for students who got help from TermPedia during the open-book test ($\bar{A}_s$) was significantly greater than the mean score for students who did not get any help from TermPedia during the test ($\bar{B}_s$). The t-test gave a p-value$= 0.139 > 0.05$ confirming that there is insufficient evidence to show that ($\bar{A}_s$) is greater ($\bar{B}_s$) as indicated by the MWW test above. We therefore accepted the null hypothesis that the means are equal, meaning that there is no sufficient evidence to show that TermPedia improved the students scores for the open-book test.

	Group A	Group B
Number of students	15	14
Median	16.00	15.50
Mean	16.33	15.43
Standard deviation	02.23	02.17

Table 3: Summary of students open-book scores with outliers ignored

The mean score ($\bar{A}_s = 16.33$) is greater than the mean score ($\bar{B}_s = 15.43$) by only 0.9, see table 3. this difference is too small to prove that TermPedia can improve the process of e-learning and improve understanding of education documents by providing contextually relevant information, in accordance with the t-test results. We attribute this to the circumstance that the sample of 15 students from each group is too small to give substantial evidence of the different performances, and clearly show the impact of TermPedia on the process of e-learning. We believe that a larger sample would evidently show that TermPedia has a positive effect on e-learning by improving students performance. In support of this we notice that the difference in the means is more than $0.5sd$ if the open-book test scores are used as obtained and still more than $0.25sd$ after the outlier is removed. This indicates potential ability of TermPedia to improve the process of e-learning, a notion that could be proved with a refined experiment on a larger sample.

B.5. Analysis of Time Spent by Students to Complete the Open-Book Test

It is worth mentioning that this test was not reliable as an indicator of learning speed since most of the students waited until the last minute to turn in their answer sheets regardless of whether they had completed the test earlier.

User group	Median	Mean	S.D.
A_t	48.00	47.00	03.98
B_t	43.00	43.87	05.46

Table 4: Table showing summary statistics of time spent by students on open-book test

Summary statistics in table 4 clearly shows that students who got help from TermPedia during the open-book test spent more time than students who did not get help from TermPedia during the test. This result is contrary to the hypothesis that TermPedia would reduce the time necessary for students to acquire information from education documents. A likely explanation for this result could be that the students who used TermPedia during the test were more occupied and looked up a lot of information, hence the slight improvement in their performance as discussed above.

IV. CONCLUSIONS

The user study gave insufficient evidence that TermPedia can improve understanding of e-content by providing contextually relevant information. The t-test of two independent samples indicated that the difference in scores between students who took the open-book test with the aid of TermPedia and those who could not benefit from TermPedia during the test was small (between $0.25sd$ and $0.5sd$) that it might be attributed to chance. However the students who used TermPedia during the open-book test performed slightly better (by 8%) compared to the students who did not use TermPedia during the test. We believe that the insufficient indication of improvement was influenced by the fact that the number of students who took part in the user study was rather small.

Similarly the alternative hypothesis that time needed for e-learning can be reduced through the use of TermPedia was rejected. Although these results are not in favour of TermPedia, we believe that the time needed by the students to acclimatise to TermPedia was exacerbated by the technical difficulties at Gulu University. Therefore the students were less familiar with functionalities and benefits of TermPedia at the time they took the open-book test. In addition, the time was affected by the fact that students did not turn in their answer sheet immediately after they completed the open-book test. This rendered the indication of the time need by a student to complete an open-book test with or without the help of TermPedia unreliable. We presume that it would have been important to motivate the students during the open-book test in some way which would have made them hand in their answer sheets immediately after completing the test. It can also be argued that the students who used TermPedia during the open-book test found the tool quite engaging and therefore spent more time looking up term definitions and explanations to the concepts in the open-book test.

V. FUTURE WORK

We plan to carry out a more refined user study with a larger sample keeping in mind that students need to be motivate during timed assessments. We are optimistic that a larger students sample will clearly show that document enrichment improves e-learning. Before we carry out a user study with a larger sample, we shall first improve the document enrichment process.

One way through which we intend to improve the document enrichment process is by improving term sense disambiguation. We propose to use information from Wikipedia info-boxes to classify and disambiguate terms with the help of support vector machines. This will also help provide contextually relevant term definitions. Another way we propose to improve the process of document enrichment is by providing pictorial illustrations for the difficult terms. We shall use images from Wikipedia info-boxes to provide these illustration. The adage "a picture is worth a thousand words" has an underlying proposition that pictorial illustrations serve a vital function, one much greater than simply substituting for an overabundance of words (Parrish, 1999). Knowledge retention could be such a function. In effect we shall not only improve e-learning but also knowledge retention with the help of pictorial illustrations.

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