Effectiveness Assessment of Open Educational Resource (OER) Development in the Academic Performance of Civil Engineering Students

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Abstract

Education is a system by which a generation becomes eligible to take over the previous generation and contributes to the progress of the human civilization. Compromise with an effective system of education means compromise with the ability of a student to play an efficient role in this development of human civilization. When an instructor instructs students to follow a hard book, many students due to financial disadvantages become incapable to collect the book. Moreover, in this era of digitalization, the students are used to carry every information they need in their pocket through electronic devices which demotivates them to learn through the book. These causes eventually drive students to sacrifice their educational goal partially or fully, as a result, a seemingly systematic educational system becomes an ineffective one. Therefore, the aim of this paper is to analyze one of the solutions to this problem which is the development of a web-based interactive educational system to replace the traditional textbook-based instructional approach. To establish this aim, Civil Engineering (CE) graduate level Risk Management course was selected as a pilot class to study through this new system. This system was created and implemented through four sequential phases each phase containing several sub-phases/ steps. The very first step towards building this system was to select the proper educational accessories and it was concluded that image and video type of Open Educational Resources (OER) would be most effective for this unique type of course. Hence, a risk management course database was created using images and current case studies related to construction management risks. Using this database, the virtual system was created and throughout the semester, the instructor and the graduate teaching assistant monitored students’ involvement in the new system and motivated them to use and be benefited through the system by assigning bonus points. At the end of the semester, a survey was conducted to collect data regarding students’ knowledge of the subject and the web-based integrated system. The collected data from the survey was assessed qualitatively and quantitatively. It was concluded after analysis that OER free materials act as a positive catalyst to better prepare students in their academic career compared to traditional textbook system. Especially students with engineering major and/or students with loan were the ones who were more suited for this system at the moment as they were the more benefited group compared to others by this system. Moreover, as this system can be monitored thoroughly, it helps the instructors to understand the toughness level of each lecture for the students by monitoring the statistics of the use of the website regularly. It was found that development of OER not only eliminated the financial burden of high cost of textbooks but also increased the involvement of the students with the subject’s resources materials and with the educators.

Introduction

Education is a very important component of every society.¹ As a result, numerous researchers have conducted several studies focusing on effective teaching and learning techniques and strategies.² Moreover, many studies have been conducted to evaluate and analyze the
effectiveness of the innovative implemented teaching methods. In this regard, some researchers concluded that one educational method or training style which is suitable for a targeted group of individuals, may not be effective for another group of people.

One of educational components which has been debated over for a very long time is utilizing traditional textbooks. A textbook is a study material which should be easily available and is organized for a specific course in a language suitable for the course takers and it is considered as the most effective aid in any educational system. This notion tempts a student to think that the textbook has every little detail needed to know about the course, however, it is never true as a textbook is always behind in the timeline compared to the students. In addition, with the growing population of pupil and dependency on a textbook for education, the demand for a textbook is increasing. Increasing demand is resulting in an increase in price making textbooks unavailable for the students who are unwilling/unable to bear extra cost for the textbooks. In fact, in United States, the prices of textbook rose around 82% from 2003 to 2013. Moreover, being an era of information technology, technological advancement is progressing at an enhanced speed with the new innovations daily and people are becoming more and more dependent on the technology for almost everything. In fact, a survey has been done and it was found out that almost 56% of American adults own a smartphone and most of the people among them are young-adults. These little gadgets provide a sensation of having almost everything needed in the pocket of a millennial. This phenomenon discourages a student to carry one or several textbooks all day for the classes. In fact, a survey conducted among several of the classes of professor Swanson resulted that more than 66% of the student look on the internet for related material for the course before looking into the textbook irrespective of whether the textbook was optional or mandatory for the course. This also indicates young student’s reluctance towards going through pages of printed textbooks. Above mentioned problems can be resolved by introducing an effective system containing Open Educational Resources (OER).

OER can be defined as an educational system where instructors and students can have access to every educational resource including course materials, videos and/or multimedia applications without paying any kind of fee or royalties. Developing an interactive web-based OER educational system should enhance the performance of the students by eliminating the burden of increased price. Besides web-based OER is very appropriate for the young adults who are very fond of technological devices hence it should encourage their attention towards their academic performance. Therefore, this paper tries to quantify this phenomenon by assessing the effectiveness of OER materials through the interactive online educational system. For this, the perception of engineering and non-engineering students about OER as well as the perception of the students with loan and without loan are evaluated.

**Literature Review**

It is an open truth that the price for the hard copies of the book is increasing. In fact, in 2013, a Government Accountability Office (GAO) studies showed that the rate at which the price of the textbook is increasing is double the rate of inflation. On an average, a student must spend around $900 for four years of school. As a result, students are becoming less likely to buy a book and the State Council of Higher Education for Virginia found out that around 60% of the students nationwide don’t buy books. The GAO blames the accessories comes with the books
like CD ROMs, websites etc. as a cause for increasing price of the textbooks. According to Koch\textsuperscript{11}, this high price of textbooks along with the increase of tuition fees made the higher education less accessible by the students. Rising price of textbooks also increasing the necessity of allocating more money as financial aid by the federal government, colleges, and universities to an increasing number of eligible students. In addition, textbook markets are a free market without any regulation by a governmental policy which makes it hard for policymakers to control prices for textbooks. Textbook markets also differ from other markets in a sense that the person i.e. the faculty who determines which book to be a textbook for a course don’t really know the price compared to the customer i.e. the students who are going to buy the book eventually. As a result, they don’t give enough consideration for price or affordability while recommending the book. Koch also recommended that publishing a new edition of the textbooks with a greater interval, selling learning packages and textbook separately, easy reselling and re-importation of textbook policies might help lower the intensity of this problem.

One of the most effective solutions to this problem can be Open Educational Resources (OER). In the early 1980s, Massachusetts Institute of Technology started the primary concepts of OER which become much developed with the constant development of software technology,\textsuperscript{12} even though the term OER came to use around 2002.\textsuperscript{13} Downes\textsuperscript{14} defined OER in two points, one is types of resources that includes software, simulations, course monitoring etc. and the other is resource media that include Information and Communication Technology (ICT). He also mentioned that these resources can be called open only when these products and services are free of cost for the user to use. QER is not only good for readers as they get access to a greater extent of literature, it is also beneficial for publishers as it enables publishers to publish varieties of articles. Some researchers are concerned about the sustainability of the OER system as this system does not produce any quick monetary benefit in return as the users of this system get access to the material for free. In addition, although this system reduces publishing cost significantly, yet it discourages publishers to invest in this system as it is unable to offer visible benefit in short time. But a system can’t be developed without a significant investment for establishment and maintenance. To solve this problem, some model has been established which are Endowment model, membership model, donations model, conversion model, contributor-pay model, sponsorship model, institutional model, government model etc. According to Johnstone\textsuperscript{15} OER not only helps students, it also helps instructors to develop their teaching methods by monitoring their own materials or by comparing their method with another instructor’s method through OER. It also helps instructor from developing countries to enrich their teaching materials timely through OER form highly developed universities.

Many researchers defined OER differently. D’Antoni\textsuperscript{16} agreed with the definition provided by United Nations Educational, Scientific and Cultural Organization (UNESCO)\textsuperscript{17} in 2002 where they defined OER as a non-commercial process which makes educational resources open to the users with the help of information and communication technologies. She explained the roles of four main stakeholders of OER system. The stakeholders are- higher education institution with the responsibility of research, awareness raising, and capacity development; international bodies with the responsibilities if copyright, financing, and standards; national governments with the responsibilities of policy support and accessibility and the fourth stakeholder are academics.
Another researcher named Hylen\textsuperscript{13} agrees with the definition of OER as digitized educational materials that are with minimum restriction as possible legally and monetarily to use by the educators, students, and self-learners and can be reused as the materials can be adapted accordingly by the users. However, making students free of the burden of buying a textbook or making the materials free and accessible by all is a controversial matter of discussion. In fact, around April 2012, a company who offered such free textbook suitable for any institution was sued by three major academic publishers.\textsuperscript{8}

Some students show preference towards global learning styles, some prefer sequential learning style. Based on the preference, course material should be recommended.\textsuperscript{14} The traditional textbook system is unable to recognize this phenomenon, where this newly developed interactive web-based system recognizes this problem based on the student's participation and feedback on the website. Instructor and graduate teaching assistant can help students in this regard based on the feedback. This effort makes the materials more suitable for the students. As a result, most of the students get benefited from development of OER system.

**Methodology and Data Collection**

A four-step research approach was adopted for this study as shown in Figure 1. First step was the review of the literature and the present condition of the students and their perception and understanding of the existing educational systems and resources. It was helpful to identify the problems of the traditional textbook dependent educational system as well as presents students' outlook towards this system and inclination towards technology. Moreover, to compare the effect of OER on different types of students, a course was chosen for this study which is offered to both engineering and non-engineering students. The graduate level Risk Management course, which is offered by the Department of Civil Engineering (CE), contains students from both construction management and construction engineering programs.

Second step was the development of the new web-based OER system and the whole process can be divided into three phases including several sub-phases and the sub-phases are shown elaborately in Figure 1. The first phase was Pre-System Development Process. Prior to the starting of the semester, a comprehensive literature review was done to understand what kind of OER suits the students most. It was found out that images and videos are the most effective types of OER, video tutorials and homework exercises are the second and third most popular item of OER respectively (Babson Survey Research Group, 2014). Based on this statistic, OER materials suitable for the students were gathered and designed. In the second phase, System-development process phase, a website has been developed with related OER materials of Risk Management and full access to reading has been given to the students. In the third phase, Post System Development Process phase, students’ involvement in the newly developed website has been monitored regularly. During the class, they were encouraged to engage themselves in the development of OER materials.

Third step was the data collection part of the study. One set of data was collected from a questionnaire survey conducted at the end of the semester to anonymously record the students’ response toward this newly developed system. Total of 12 engineering students and 37 management students voluntarily participated in this survey. However, the number of response
for each variable might vary as some of the questions of the survey was left blank by some of the participants. The questionnaire survey mostly following a Likert system of questions included 19 variables and the students were assessed based on their degree program and financial status.

In fourth step, collected data was analyzed. A statistical test method, two sample t-test, was selected for analyzing the data which has been described later in this paper. This test has been selected because it is best suited to establish the purpose of the study which is to get a clear understanding over the perceptions towards the web-based interactive OER materials of the students of different academic and financial background material. In addition, different statistical charts were developed to understand the nature of the data in this section and multiple comparative analysis were done between groups of students and in between different variables.

Data Analysis

Hypothesis for the First Set of Analysis: Engineering and non-engineering students
Null Hypothesis: $H_0 =$ There is no significant difference between the perception of engineering and non-engineering students towards OER materials.
Alternate hypothesis, $H_a =$ There is a significant difference between the perception of engineering students and non-engineering students towards OER materials.

Hypothesis for the Second Set of Analysis: Students with loan and without loan
Null hypothesis, $H_0$: There is no significant difference between the perceptions of students with loan and students without loan towards OER materials.
Alternate hypothesis, $H_a$: There is a significant difference between perception of students with loan and students without loan.

The two sample t-test which was utilized in this study, is a hypothesis testing system which compares the mean of two groups to determine whether there is a significant difference between the mean of two groups or the difference is generated randomly. For this study, two sample t-test was performed for both the pairs separately. For each pair, two hypotheses were developed as explained earlier. Data from each group was compared with the other set through utilization of two-sample t-test and the corresponding p-values were calculated. P-values then compared with a predetermined level of significance. For this study the author chose 10% as level of significance. This illustrates that a p-value greater than 0.1 agrees with the null hypothesis and a
p-value smaller than 0.1 reject the null hypothesis by supporting alternate hypothesis. The Authors used SPSS statistics software for their calculations of t-tests. A sample outcome of SPSS statistics software is shown in Figure 2 for the variable 9 (comfort while using material) for engineering and non-engineering students.

<table>
<thead>
<tr>
<th>Null Hypothesis</th>
<th>Test</th>
<th>Sig.</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>The distribution of NonEngineeringStudentsVsEngineeringStudents9 is the same</td>
<td>Independent-Samples</td>
<td>.001</td>
<td>Reject the null hypothesis.</td>
</tr>
<tr>
<td>across categories of v2.</td>
<td>Kruskal-Wallis Test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Asymptotic significances are displayed. The significance level is .10.

Fig. 2. Sample Result of SPSS statistics software for V9 of engineering and non-engineering students.

Results

The web-based OER system can help student by providing plenty of useful features, keeping that in mind, 19 variables were selected, and Figure 3 makes it clear that these features were well liked by the majority of the students. For example, around 90% of the students thought that this system provides better quality visuals and also helped them to review and remember material more easily compared to traditional textbook system. Most importantly, around 90% students believed the outcome after using this system compared to the traditional textbook system was better which helps them redeem the money they paid for tuition as good result. However, a further discussion is presented to determine the suitability of OER for the groups in following paragraphs.

Fig. 3. Graphical Representation of percentage of the students’ preference towards OER materials for different variables.
Pair 1. Engineering and non-engineering students

As shown in Table 1, irrespective of their major, students found OER helpful as it enables them to access course material whenever they needed (p-value- 0.101) and also provides good search capabilities (p-value- 0.151) for a particular topic compared to the traditional textbook system. This quality of OER encourages them to take useful notes on the materials (p-value- 0.531). Thus, OER shut out other distractions while studying (p-value- 0.295) and make the students more attentive. However, different branches of educational choices prepare students to process information differently. Hence some students are more benefited by some of the variables than the other. For example, engineering students are more research-oriented and interested in the basic principles of engineering whereas management students are more into the practical application of the knowledge they acquire. For this reason, former group of students are more likely to spend much interest towards the high-quality visuals (p-value- 0.05) and useful and helpful aids (p-value- 0.062) OER offers which helps them to find relative (p-value- 0.042) and current content (p-value- 0.083) compared to traditional textbook system. As it is an interactive system, students can collaborate with fellow students (p-value- 0.042), they can be prepared for class activities or discussions (p-value- 0.091) by reviewing and remembering the material (p-value- 0.041) which OER offers but traditional textbook system can’t, and engineering students agree with this more confidently compared to non-engineering students as p-value indicates.

Table 1. P values of OER variables of engineering and non-engineering participants and students with loan and without loan

<table>
<thead>
<tr>
<th>Serial</th>
<th>Variables</th>
<th>P values for Engineering and non-engineering students</th>
<th>P values for students with loan and students without loan</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>Cost of study material</td>
<td>0.064*</td>
<td>0.08*</td>
</tr>
<tr>
<td>V2</td>
<td>Good search capabilities</td>
<td>0.151</td>
<td>0.087*</td>
</tr>
<tr>
<td>V3</td>
<td>High-quality visuals</td>
<td>0.05*</td>
<td>0.242</td>
</tr>
<tr>
<td>V4</td>
<td>Engaging and interesting writing</td>
<td>0.03*</td>
<td>0.258</td>
</tr>
<tr>
<td>V5</td>
<td>Understandable and clear writing</td>
<td>0.06*</td>
<td>0.093*</td>
</tr>
<tr>
<td>V6</td>
<td>Helpful and useful aids</td>
<td>0.062*</td>
<td>0.074*</td>
</tr>
<tr>
<td>V7</td>
<td>Relative content to the course</td>
<td>0.042*</td>
<td>0.074*</td>
</tr>
<tr>
<td>V8</td>
<td>Material on current content</td>
<td>0.083*</td>
<td>0.076*</td>
</tr>
<tr>
<td>V9</td>
<td>Comfort while using materials</td>
<td>0.091*</td>
<td>0.054*</td>
</tr>
<tr>
<td>V10</td>
<td>Good Value for the paid price</td>
<td>0.114</td>
<td>0.038*</td>
</tr>
<tr>
<td>V11</td>
<td>Access course material whenever needed</td>
<td>0.101</td>
<td>0.067*</td>
</tr>
<tr>
<td>V12</td>
<td>Get started on correct assignments in time</td>
<td>0.066*</td>
<td>0.09*</td>
</tr>
<tr>
<td>V13</td>
<td>Read and understand the material</td>
<td>0.072*</td>
<td>0.073*</td>
</tr>
<tr>
<td>V14</td>
<td>Shut out other distractions while studying</td>
<td>0.295</td>
<td>0.228</td>
</tr>
<tr>
<td>V15</td>
<td>Take useful notes on the material</td>
<td>0.531</td>
<td>0.068*</td>
</tr>
<tr>
<td>V16</td>
<td>Complete assignments on time</td>
<td>0.066*</td>
<td>0.083*</td>
</tr>
<tr>
<td>V17</td>
<td>Review and remember the material</td>
<td>0.041*</td>
<td>0.09*</td>
</tr>
<tr>
<td>V18</td>
<td>Be prepared for class activities or discussions</td>
<td>0.091*</td>
<td>0.192</td>
</tr>
<tr>
<td>V19</td>
<td>Collaborate with fellow students</td>
<td>0.042*</td>
<td>0.081*</td>
</tr>
</tbody>
</table>

*indicates significant difference with 90% level of confidence
In addition, for this system, students don’t have to carry a book which makes studying comfortable while using (p-value- 0.091) OER resources, also OER helps students find and get started on correct assignments on time (p-value- 0.066) which enables them to complete the assignments on time (p-value- 0.066), as engineering students are more fond of this system, obviously they become more interested in this system and had to spend less cost for study material (p-value- 0.064).

**Pair 2. Students with loan and without loan**

As it is illustrated in Table 1, although irrespective of their way of managing tuition, most of the students found that OER prepares them for class activities or discussions (p-value – 0.192) more effectively than traditional textbook system by providing high-quality materials (p-value- 0.242), engaging and interesting writing (p-value- 0.258) and by shutting out other distractions while studying (p-value- 0.228), some of the students found some qualities of OER system more helpful than others especially students with loan. Students with loan are the ones who have more financial constraints and they might not have the ability to purchase course book, in fact, the very first variable agrees with this assumption as it shows that students with loan are less willing to bear the cost of study material (p-value- 0.08) compared to students without loan. This unwillingness encourages them to utilize the OER system to its fullest, as a result, they get benefited by OER offers like better search capabilities (p-value- 0.087), relative (p-value- 0.074) and current content (p-value- 0.076), helpful and useful aids (p-value- 0.074), access material whenever they needed (p-value- 0.067) better than the students without loan. They also feel more comfortable while using (p-value- 0.054) OER materials compared to students without loan. The box plots of Figure 4 and the p-value (0.068) for the variable take useful notes on the material also show that students with loan are more effective in taking notes using OER materials compared to students without loan. This behavior helps them to read and understand the material (p-value- 0.09), find and get started on correct assignments in time (p-value- 0.09) and complete the assignment on time (p-value- 0.083).

![Take useful notes on the material](image_url)

**Fig. 4.** Box plot for the responses given by students with loan and without loan on taking useful notes of the material
Moreover, as the students have access to material in this system as opposed to traditional textbook systems, they are more collaborative with fellow students (p-value - 0.081) than students without loan who are more dependent on the textbook. Hence, students with loan find outcome this system gives as good value for the price (tuition) they paid (p-value - 0.038) compared to students without loan. Based on this discussion it can be said that offering free materials will release some burden form students with loan and increase their preparedness which makes them more prepared for class with OER than students without loan.

Based on the earlier discussions and Figure 5(a), it can be said that as most of the identified OER variables favor the alternate hypothesis for pair 1. It is evident that engineering students will be more benefited from the web-based OER system compared to non-engineering students. However, perception of the students for most of the variables gets affected by the fact of having loan for tuition fees. From Figure 5(b), it can be seen that except very few variables most of the variable supports the alternate hypothesis of the second set of analysis. This means that OER material enables students with loan to prepare for future better than students without loan.

![Fig. 5. Ratio of number of significant variables to non-significant ones (a) for engineering and non-engineering students & (b) for students with loan and without loan.](image)

**Conclusion**

This study analyzed and assessed the usefulness of web-based OER materials to eliminate the problem of increasing price of textbooks and the problem of dependency towards technology at this present era. After analyzing the data in various statistical ways, the results were presented in a self-explanatory way using charts and diagrams and tables. Based on these, three propositions could be made. Firstly, OER based free material helps students significantly much more than a traditional textbook system to improve their academic performance. Secondly, students with engineering major get more positively affected by OER material compared to non-engineering
students. Thirdly, students with loan get more positively affected by the free materials that OER offers than students with no loan. From these three corollaries, the authors concluded that though OER is helpful for every student, OER material is best suited for students who are studying engineering majors and/or students with student-loan. The findings of this study help funding program managers to effectively distribute and award OER grants, and also invest the resources in areas/majors were the best outcome could be obtained.

Acknowledgement

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