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ABSTRACT

As part of a longitudinal analysis of user experience in an eLearning system, this paper reports on an exploratory study that investigated the relationship between patterns of usage and measures of student outcomes. The data was collected over a semester of an undergraduate and postgraduate course on Information Systems of 135 students working in a blended learning environment. A survey was also conducted at the end of the semester to measure the students’ perceptions and evaluation of self-efficacy. The data indicates that there are some consistent usage patterns and higher levels of eLearning system engagement for higher than average performing students. Outcomes of the study have also been analyzed to provide insights into features of eLearning systems that can potentially contribute to improved learning outcomes.

Keywords  
eLearning, academic analytics, learning experience, blended learning

INTRODUCTION

Like many higher learning institutions (HLI) globally Australian universities are undergoing rapid changes due to ongoing government reforms in higher education, increased accountability, competition from abroad, as well as changes in the composition and expectations of student body. The Australian government targeted projection at achieving 40% of those from 25 to 40 having a bachelor degree by 2025 and at the same time the increasing number of the new generation of “netizens” almost inevitably posits an increasingly critical role for the presence of eLearning in higher education. Most HLIs in Australia are still conducting courses in conventional ways and encompassing a form of blended learning (Graham et al. 2006) in which the lecturers deliver face-to-face lectures supplemented with tutorials, laboratory works and some forms of eLearning tools. Learning Management Systems (LMS) are common for the management and administration of courses such as providing schedule, tracking of the progress of courses, providing newsgroups as well as acting as a repository for uploading and downloading of learning materials. Increasingly eLearning tools are introduced in more courses to complement learning of concepts and providing a platform for students to test their understanding and application of the concepts they learned as a result of attending lectures and tutorials.

Alongside many of the HLIs efforts into improving student learning outcomes we have seen the concept of ‘academic analytics’ (Campbell et al. 2007) gaining momentum as a process for providing data to respond to the reportage and decision making challenges facing higher institutions. In addition to conventional data such as students’ demographics and academic performance, this data can be extended by capturing student behavior through user online interactions whilst using LMS, such as student access to learning resources, facilitation of student-student, student-tutor and student-lecturer interaction, participations within newsgroup, forums and possibly social networks. These data can not only be used to promote practitioner reflection for professional development and pedagogy adoption as well as identifying students who may require additional learning support but also for providing useful feedback to peer learners through recognition of successful learning experiences (LE) to improve and optimize learning outcomes.
Despite the large volume of data captured and recorded there is a lack of studies conducted on the effects of user experience and behaviors in using an interactive eLearning system with respect to the learning outcomes. In this paper, we report on a study, which is part of a longitudinal study to identify and recognize successful learning experiences through an analysis of the general patterns of usage, level of engagement and level of understanding that learners have in an interactive eLearning system through the collections of usage statistics.

The rest of the paper comprises of the following. The background section discusses related work and provides some context to learning experience in eLearning and its relation to user learning experience and learning patterns. The following sections discuss the eLearning platform to provide a big picture of a blended interactive eLearning environment in which this study was conducted. A proposed research design is described and examined. The results are then presented followed by a detailed discussion on the study findings and expected future works.

BACKGROUND

An eLearning system typically comprises three essential components: Human, knowledge and technology (Refer to Figure 1). The nature of learning process is a transfer process between tacit and explicit knowledge. In eLearning knowledge is related to many experiences that are human oriented. In his sociocultural theory, Vygotsky (Vygotsky 1980) argues that individual mental functioning is inherently situated in social interactional, cultural, institutional and historical contexts, and learning occurs through social interactions with peers, mentors and experts. Very often the human dimension encompasses a deeper meaning such as: human as activities subjects, human-based social network and human-based social culture.

![Figure 1. HKT Paradigm](image)

Human knowledge is also created and expanded through social interaction between tacit and explicit knowledge. According to Nonaka and Takeuchi (Nonaka et al. 1995) tacit and explicit knowledge are mutually complementary. Michael Polanyi (Polanyi 1967) first pioneered tacit knowledge encapsulated into his statement “we can know more than we can tell”. Tacit knowledge is regarded as being subjective in nature, and is developed by an individual based on his cognitive and conceptual models of external processes. Tacit knowledge is often difficult to identify, quantify, formalize and is largely unspoken and implied. Explicit knowledge on the other hand is objective in nature, quantifiable, definable, and mainly consists of theory serving as instructional materials that can be tested rationally and repeatedly over time. The two forms of knowledge are highly interdependent and inextricably interwoven and the interaction of these two is called the “knowledge conversion” process which can be illustrated by SECI model: (1) Socialization (tacit to tacit); (2) Externalization (tacit to explicit); (3) Combination (explicit to explicit) and (4) Internalization (explicit to tacit). Nonaka believes that this four four-step knowledge conversion process is the key to knowledge creation. Furthermore if the interaction of these two forms of knowledge becomes larger in scale as it moves up to higher ontology levels, knowledge synthesizing and sharing become part of the culture of an organization.

Learning process is therefore the process of knowledge transfer between tacit and explicit knowledge. As in any other learning forms, knowledge evolution, use/reuse, and sharing should be highlighted as the essential learning goals of eLearning. Learning services however should be geared towards striking a balance between human, knowledge and technology in eLearning context to accelerate and optimize maximum learning efficiency.

In eLearning the explicit knowledge is presented to learners in the form of instructional materials, course notes, quizzes, etc, and quite often abundant and excessive due to advances in information and communications technologies. Instead what is of value is the meta-information. That is, knowledge of the type of information, when it is useful, what to do with it and how to reuse it. Tacit knowledge of learners, according to researchers (Nonaka et al. 1995; Ronchetti et al. 2004), is the answer to these questions. Learning experience (LE) also holds the key to the answer because it reflects a learner’s cognitive, behavioral and psychological learning pattern, which is in fact a form of tacit knowledge.
Yi (Yi 2006) argues that sharing one’s own experience in an online environment is the most effective way for people to share their tacit knowledge. The few works identified in literature are Teo and Gay (Teo et al. 2006), who use concept map and formal concept analysis to tap and externalize the expert’s or mentor’s tacit knowledge and used it to personalize eLearning system. Peter Dolog’s (Peter Dolog 2008) research works focus more on the framework and infrastructure of eLearning system that enables personalized access to distributed heterogeneous knowledge repositories. He addresses the key issues of choosing the appropriate learning repositories with a vast number of federated learning offers. There are also many works that identify potential differences in online behavior between high and low performing students using analytics on LMS statistics (Campbell et al. 2007; Coates 2005; Goldstein et al. 2005) but not specifically on any interactive eLearning tool.

Essentially assessing eLearning cannot be evaluated using a single linear methodology. In this exploratory study we use analytics data collected from user interaction with an interactive eLearning tool and build a multi-dimensional approach to survey the effect of eLearning engagement and experience on the performance outcomes, which accordingly consists of three major measurement (Kraiger et al. 1993): Cognitive (directly from GPA based performance), affective (self-efficacy belief and perception of course)) and skill-based (directly from GPA based performance). The survey we designed takes into consideration the learners’ reaction and self-efficacy which we hypothesize as having direct impact from eLearning engagement and also have a hidden complexity and dynamism as a mediation role contributing to better GPA performance outcome. The study outcomes provide insights into improving eLearning features, feedback in the form of learning engagement and also have a hidden complexity and dynamism as a mediation role contributing to better GPA performance.

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**ELEARNING PLATFORM**

In many HLIs today, the environment is increasingly shifting into blended type of learning where in addition to the traditional model of face-to-face lectures, tutorials and laboratories, eLearning components such as, discussion forums, newsgroups, social networks and some interactive eLearning tools are introduced to complement learning. When learners start to engage with learning the core learning activities still take place in the traditional in-class face-to-face lectures, tutorials and laboratories.

In our setup, the main eLearning tool is called Learning Database Management (LDBM), which is an interactive eLearning tool, developed to complement and enhance concepts relating to relational databases learned in the lectures. Students’ interactions with the eLearning tool are all logged and the data are collected and analyzed for their experiences in terms of the learning trends, the frequencies of interactions, the time they spent on the activities and their learning patterns.

LDBM is a 24/7 online eLearning tool developed in addressing the growing need for database competency in graduates across a range of disciplines at the University of Queensland. A recent review at the university disclosed that it is no longer a course that is exclusively taken by computer science or IT students and therefore is widely taken by other non IT disciplines such as science, engineering, business etc. The tool was designed to support the growing trend by ensuring that the core concepts of database management are presented in a manner that provides a meaningful context and connections to the professional and personal experiences of the diverse student body.

The tool consists of learning objects and examples which students are free to select. A large number of examples have been prepared across a range of domains and include areas such as marine studies, urban planning, scientific experimentation, human resource management etc. For instance coral bleaching in marine studies was used as a case study for monitoring the effect of coral bleaching across the Great Barrier Reef of Australia.

**RESEARCH MODEL AND HYPOTHESIS**

We regard eLearning tool as one sort of self-directed and regulated learning behavior. Individual engagement in eLearning tool can have a direct impact on student’s learning outcomes and GPA performance. More importantly we also argue that individual learning process with eLearning tools is composed of: 1) self-efficacy beliefs and 2) satisfaction or the learners’ perception of a course, in a blended learning environment. These two are also the prominent mediators between online engagement and the GPA-based outcome.

Accordingly, Bandura’s social learning theory (Bandura 1986; Bandura et al. 2003) stresses the self-regulation of learning, suggesting that individual self-directed active engagement functions as an initial motive for achieving desirable learning outcomes. In most cases, individual will self-initiate, regulate learning and actively construct knowledge by acquiring, generating, and structuring information.

As eLearning provides a new platform for HLI students’ learning, individuals are provided with an alternative channel to learn at any distance in time and space. To activate such learning, time and energy are devoted to the eLearning online site. Thus eLearning provides a user more opportunities to be an active and self-regulatory learner. For example learners can
control the learning time and procedures by themselves thus creating a self-autonomy environment. Self-efficacy as defined by Bandura (Bandura 1997) refers to personal beliefs about one’s capabilities to learn or perform skills at designated levels. As eLearning environment usually offers collaborative, interactive, network systems and multimedia contents, they offer a learning environment to improve learner’s problem-solving capabilities and thinking skills. In this way, learners acquire information to appraise their self-efficacy from their performance accomplishments, vicarious experiences, and forms of persuasion. Thus in eLearning, learning activities centre around learner autonomy and interactive learning actions. Further more it also incorporates learning opportunities between instructors and learners and amongst learners. And according to Rosenberg’s (Rosenberg 1965) approach, eLearning offers more opportunities for improving problem solving capabilities, enhancing high order thinking skills, and achieving learning effectiveness (Chen et al. 2005; Liaw 2004). Based on these criteria we hypothesize that:

H1: Students’ eLearning engagement is positively related to their academic performance (GPA).

H2: Students’ eLearning engagement is positively related to their self-efficacy belief and

H3: Students’ eLearning engagement is positively related to their satisfaction or perception of course.

A supportive environment is also a key to individuals attaining desirable learning outcomes. This is usually reflected through reactions or the learners’ perception of the course. It is also one of the most widely used variables to measure the learners’ satisfaction at the end of a course. Although some literatures argue that the perception of course by the learners is not necessary useful for providing evidences as to whether it influences learners’ outcome, we nevertheless hypothesize that:

H4: Students’ course perception is positively related to their academic performance.

Individual self-efficacy beliefs influence their thought, emotional reactions and behavior (Bandura 1997). People do not seek out or enjoy doing things that they believe they cannot do well. People with high efficacy beliefs are more willing to persist in tasks, reduce fear and anxiety, have positive emotions, focus on problem-solving strategies and therefore achieve a high level of outcomes (Steinfield et al. 2008). Self-efficacy beliefs make individual students feel confident of their capabilities of performing tasks. This indicates important evaluative information for student to positively appraise themselves which contribute directly to individuals’ performance attainment, including academic achievement and work-related performance (Bandura 1997). Thus we hypothesize that:

H5: Students’ self-efficacy belief is positively related to their academic performance.

The proposed research model is shown in Figure 2.

METHOD

Our research method consists of collecting data relating to the students’ interactions with LDBM and administering a survey at the end of the course. The population selected to run our experiment comprised of undergraduate and postgraduate students in the course “Introduction to Information System” (INFS). The course has a student size of 135 from diverse backgrounds and disciplines. The course has 3 hours lectures, 1 hour tutorial and 1 hour practical every week. As part of the assessment there were 2 quiz exams, 1 assignment during the semester, and 1 final exam at the end of the semester. The students’ interactions with the LDBM were recorded over the semester.

Learning Outcomes

Learning Outcomes consists of cognitive, affective and skill-based (Kraiger et al. 1993). Cognitive is knowledge-based which is associated with deep learning and thus the outcomes include knowledge, comprehension and application. Generally the final grade reflects the cognitive aspect of an outcome. Attitude-based affective learning includes students’ attitude, satisfaction, being, relationships, and the ability to deal with situation. Therefore affective learning outcomes include students’ satisfaction, attitude and appreciation of the learning experience. Research has shown that self-efficacy is a strong indicator of training transfer (Brophy 2004; Sitzmann et al. 2008; Zimmerman 2000). The usual method to assess self-efficacy or affective outcomes is through survey questions and this is also the common practice in many training evaluations. Skill-based domain of learning outcomes is concerned with development of critical thinking and the technical skills to solve problems or perform tasks and thus it is also directly reflected from the final grades of students.

Learning Experience

Time devoted to study has long been considered an important variable in the measurement of learning experience (Brennan et al. 2009). In our study, students learn the concepts of database management system in the conventional model. To test and supplement their learning they could login to LDBM at their own initiative and work through the examples. The LDBM records each time a student submits a question and accumulates as counts. Learning experience of LDBM therefore consists of the time the learner spent, each time a student attempted and submitted a question, and the patterns of questions they
attempt. Looking at the structure and functions of LDBM, the counts of attempting and submitting questions are more meaningful than time spent on using the LDBM considering the fact that learner could leave an open session of LDBM for hours without logging out and come back later to continue. Therefore the counts of submitting questions are being used as the variable for eLearning engagement to measure the effects of learning experience. It follows that the more counts or the more attempts a student made, the larger the experience and the amount and quality of learning that might accrue from it. Therefore the records of counts of each learner indicate a true picture of learning in our research.

Measures
In the survey questions, we used 5-point Likerd scale to measure the variables of self-efficacy and course perception of students, one being strongly disagree and 5 being strongly agree, and treated the submission of questions to the eLearning tool as a measure for individuals’ online eLearning engagement. We adopted 11 items related to self-efficacy belief and 12 items related to students perception of course (Goldstein 1986; Kirkpatrick 1975; Kraiger et al. 1993). Accumulated GPA ranging from 1 to 7 aggregated from 2 inter-semester quiz exams, 1 assignment and a final semester exams measured performance outcomes of students.

RESULTS AND DISCUSSION
The number of students using LDBM was only 108 and 27 students were not using. Table 1 indicates the percentage of students’ eLearning engagement and percentage of students with respect to their performance outcomes.

<table>
<thead>
<tr>
<th>GPA Performance Grades</th>
<th>7</th>
<th>6</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of eLearning engagement</td>
<td>23.59</td>
<td>33.09</td>
<td>16.61</td>
<td>20.57</td>
<td>2.44</td>
<td>3.7</td>
<td>0.01</td>
</tr>
<tr>
<td>% of students achieving</td>
<td>13.33</td>
<td>23.70</td>
<td>16.30</td>
<td>25.19</td>
<td>3.7</td>
<td>11.85</td>
<td>5.93</td>
</tr>
</tbody>
</table>

Table 1. Level of eLearning Engagement And Experience with GPA Outcomes

<table>
<thead>
<tr>
<th>GPA Outcomes</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation Coefficient</td>
<td>1</td>
<td>.378**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sig. (1-tailed)</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>108</td>
<td>108</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Correlation is significant at the 0.01 level (1-tailed)

Table 2. Correlation of GPA to eLearning engagement and experience

We measure the correlation of eLearning engagement to the GPA performance outcomes of the 108 students and the result is shown in Table 2.

In the survey questions the number of students who responded were 50 in which 2 did not participate in the LDBM. We measure the correlation of eLearning engagement to GPA performance, self efficacy, course perception as well as self-efficacy and course perception to GPA performance with sample size of N=48, respondents of survey questions. The results are shown in Table 3.

All variables and measures were analyzed for reliability and validity in accordance with the guideline set out by Joreskog and Sorborn, (Joreskog et al. 1993). The reliability of these constructs was evaluated using Cronbach’s coefficient (α) and the calculated values were all above 0.7 indicating a reliability measurement instrument. We assessed convergent validity by examining a composite reliability (CR) and average variance (AVE) extracted from the constructs. Table 4 indicates CR values are higher than the suggested minimum of 0.7 and AVE values were all above 0.5 thus providing evidence of convergence validity.
The relationship of eLearning engagement, course perception and self-efficacy were further tested using Smart PLS, a multiple regression analysis. Partial-least squares were used to test the hypothesized relationship among the variables in the model. PLS is a second generation multivariate technique that facilitates testing of the psychometric properties of the scales used to measure a variable, as well as estimation of the parameters of the structural model i.e. the strength and direction of the relationship among the model variables (Fornell 1987). Table 5 shows the summary of the results. The models’ predictive power was also assessed by measured $R^2$ for endogenous variable (Fornell 1987) for H1 and H4 and H5.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Direct Factor</th>
<th>B</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>GPA</td>
<td>.584**</td>
<td>Supported</td>
</tr>
<tr>
<td>H2</td>
<td>Self Efficacy</td>
<td>.184**</td>
<td>Supported</td>
</tr>
<tr>
<td>H3</td>
<td>Perception of course</td>
<td>.139</td>
<td>Not supported</td>
</tr>
<tr>
<td>H4</td>
<td>GPA</td>
<td>.430**</td>
<td>Supported</td>
</tr>
<tr>
<td>H5</td>
<td>GPA</td>
<td>.400**</td>
<td>Supported</td>
</tr>
</tbody>
</table>

$R^2$ for H1 = 19%
$R^2$ for H4 and H5 = 2.8%

**Indicate statistical significant at p<0.05

The result in Table 1 clearly shows that students with performance outcomes of 6 and 7 have the highest eLearning engagement, 23.59% and 33.09% respectively. In fact students with high performance outcomes of 7,6 and 5 constitute 73.29% of the total usage. And that of outcomes of 7,6,5, and 4 (passing grade being 4) is 93.85%. Those who failed the course (outcomes of 3,2 and 1) have very low eLearning engagement and experience and only constitute 6.15% of the total usage. The correlation in Table 2 is indicative of strong positive impact of eLearning engagement to GPA outcomes across the population (p=0.542).
Our hypothesis model in Figure 2, and the results in Table 3 suggest strong association of substantial impacts of eLearning engagement on student learning experience and the subsequent learning outcomes, across the population (Table 1) as well as to those respondents of the survey questions. As shown under H1, the result positively indicates that eLearning engagement has direct impact on students’ learning leading them to a higher GPA performance outcome (B=0.584).

The results also illustrate the mediation effects of two attributions of eLearning that transforms individual online learning engagement into GPA performance outcomes. First eLearning engagement promotes their self-efficacy belief (B=0.184), H2. Such believe substantially leads them to achieving higher GPA outcome, hypothesis H5 (B=0.400), confirming the central role of self-autonomy in eLearning.

Secondly, students’ eLearning engagement does not support learners’ course perception (B=0.139), hypothesis H3. But in hypothesis H4 (B=0.430), perception of course has positive effect on the GPA outcome, is supported as indicated in Figure 2. This suggests an overall learning experience of positive effect on the learning outcomes.

The study also suggests that there is a difference in eLearning engagement between high performing and low performing students. Although further research is needed to substantiate this point, it can be argued that low-performing students may not be optimizing their eLearning engagement in the same way their higher-performing counterparts are able to which could be due to their struggle with the level of discipline and intrinsic motivation required for this type of learning. As noted by a number of researchers, eLearning demands high levels of motivation, discipline, persistence and academic integration from students in order to perform well.

We must also acknowledge that several open questions still exist in our research. First our results demonstrate a partial mediation effect of eLearning engagement and learning outcomes. We believe that there is a more complex and dynamic evolution from eLearning activities to the ultimate learning outcomes in which rich psychological and sociology processes are hidden. Thus future research could continue to investigate other potential intervening factors, linking eLearning engagement to learning outcomes. For instance the implications of genders, background, initial level of knowledge, attendance of lectures as well as tutorials, and other eLearning tools like discussion forums that also played a role in the blended learning environment could be interesting areas for further research which have different learning objectives and outcomes.

The selection of LDBM as an interactive eLearning tool for our experiment may help to reduce the complexity and variety of individuals’ eLearning engagement, however such specificity might make the investigation of eLearning engagement behavior superficial.

According to social learning theory, learning is an interpretation of human behavior in terms of a continuous reciprocal interaction between cognitive, behavioral and environmental determinants. Our study, although with data triangulation, is still limited in the conclusion of causality as well as the detection of the interrelationships between included factors. For example the achieved learning outcomes can reciprocally lead individuals to more active engagement in eLearning engagement and more enthusiastic participation. Therefore in the future, research could investigate the reciprocity amongst eLearning engagement and learning outcomes in order to find out the dynamism of individual eLearning engagement. It is also worthwhile in the future work to include a control group that is characterized through alternative study modes such as active...
participation in newsgroup, high attendance in tutorials etc and not necessarily active on LDBM. We expect this to provide further insights in understanding the role of the eLearning tool for improved learning outcomes.

**CONCLUSION**

In this paper, we investigated the learning experience of students using interactive eLearning tool by capturing the eLearning engagement and experience of usage in order to study the impact with respect to the learning outcomes. There is a strong indication that eLearning engagement has a positive impact on the GPA based learning outcomes. And self-efficacy belief as well as perception of course resulted from eLearning engagement also demonstrates critical roles in the learners’ outcomes.

There is also a clear indication that future blended learning will incorporate and adopt eLearning in HLIs not because of its “nice to have” features or trendy “fashion” as part of the course features to attract more students but it presents an increased opportunity not only to learners to improve their learning but also for instructors and administrators to monitor students’ activities and interactions. The analysis of these data sets is directly relevant to student eLearning engagement and evaluating implemented learning activities. While data examined are indicative at this stage, the interpretation of results discussed here may be influenced to some degree by a number of external variables, the findings nonetheless provide new insights into student learning that complement the existing array of learning and evaluative methodologies.

Although HLIs have widely adopted eLearning, the extraction and reporting of captured data has often been fragmented, with poor visualization tools militating against effective interpretation and subsequent user-action. The reporting of data derived should be accessed and implemented into current suite of tools available for teaching staff to allow better understanding of the student cohort learning behaviors, and thus an improved capacity to respond to their immediate learning needs and to assess the impact of enacted learning and teaching activities. This can also be used to inform senior management in decision-making process with regards to future ICT related activities, and enable individual instructors to evaluate student engagement and the impact of implementing learning and teaching practices.

This study therefore provides a platform for further investigations into monitoring and visualization tools to provide new data sets to inform instructors for continuous improvement for pedagogical practice and recommendation for peer learners to improve their learning outcomes.

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