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Impact of Personalized Recommendation and Social Comparison on Learning Behaviours and Outcomes

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Abstract

ELearning suffers from the lack of face-to-face interaction and can deprive learners from the benefits of social interaction and comparison. In this paper we present the results of a study conducted for the impact of social comparison. The study was conducted by collecting students' engagement with an eLearning tool, the attendance, and grades scored by students at specific milestones and presented these metrics to students as feedback using Kiviat charts. The charts were complemented with appropriate recommendations to allow them to adapt their study strategy and behaviour. The study spanned over 4 semesters (2 with and 2 without the Kiviats) and the results were analysed using paired T tests to test the pre and post results on topics covered by the eLearning tool. Survey questionnaires were also administered at the end for qualitative analysis. The results indicated that the Kiviat feedback with recommendation had positive impact on learning outcomes and attitudes.

Keywords

ELearning, learning experience, social comparison, recommender, Kiviat chart.

INTRODUCTION

ELearning systems' characteristics such as liberating interactions between learners and instructors, or learners and learners, and removal of the limitation of time and space fulfil the requirements for learning in a modern digital knowledge society. With the increasing number of so-called digital residents, and paradigm shifts in educational design, the use of eLearning approaches is on the rise in academic, corporate and consumer fields. Although we do not as yet see eLearning completely replacing the conventional learning, it is making its inroads into higher education institutions mostly in the forms of Learning Management Systems (LMS) (Allen et al. 2008) for management of courses and into eLearning tools mainly in complementing conventional learning. The eLearning tools are typically providing platform for students to test their understanding and application of concepts they learnt as a result of attending lecturers and tutorials.

However studies and surveys suggest that eLearning has yet to make a significant impact on the quality of teaching and learning and pedagogical innovation. Researchers also show that major part of the investment in eLearning is mainly focussing on the management of courses such as automation of the process of teaching and delivering of courses with the advantages of eliminating time and space barrier. The value towards better quality learning outcomes is still an area of debate and study, although some researchers have recognised the issues and provided innovative solutions to solve some related problems (Brusilovsky and Millan 2007; Peter Dolog 2008; Yalcinalp and Gulbahar 2010).

In eLearning face-to-face contact with educators, lecturers, facilitators and tutors is reduced to minimal and none at worst. The lack of opportunity for learners to interact normally in eLearning environment deprives students of "social learning". According to Vygotsky (1980) a large part of learning takes place in social interaction. Therefore the values of sharing and comparing learning experiences which is often neglected in eLearning can be of great benefits to learners, teachers, academicians and practitioners epistemologically and financially (Helic 2007; Helic et al. 2004). We argue that capturing the learning patterns and behaviours of learners and using the knowledge embedded in these patterns can be of high value for lecturers and peer-learners. In particular this paper focuses on studying the impact of sharing this knowledge to provide social comparison and recommendation. Our approach is to extract/collect data relating to the learning engagement of students with

eLearning tools, attendance in formal contact sessions (lectures and tutorials) and performance grades, and uses it analytically to better understand learning patterns and behaviours. We then derive inspiration from Social Comparison theory (Buunk and Ybema 1997; Suls and Wheeler 2000), and use the collected data and analytical methods to device a visual feedback system using Kiviat charts and providing personalized recommendations for students. We collected data over 4 semesters and used *paired T test* to validate our experiment. We also administered survey questionaries in the last 2 semesters when the Kiviat feedback with recommendations was introduced to get qualitative feedback from the students concerning the visual feedback systems.

The overarching aim of this work is to develop insights and deep understanding on how knowledge on learning experience can be effectively managed and utilized to promote improved learning outcomes across diverse student bodies within eLearning communities. The course where the experiment was conducted involves both undergraduates and postgraduates, and has a student body that spans across IT, business, engineering, science as well as a number of other academic disciplines.

In the subsequent sections, we first present the background and related studies on social comparison and learning experience in the context of eLearning. We then introduce the process of visual feedback and recommendation generation as well as the context of the study. The methods and measures are described and examined in the following section. Discussion of the results is followed and the key findings and future extensions of this work are summarized in the last section.

BACKGROUND AND RELATED WORK

Festinger's (1954) social comparison theory states that "There exists, in human organism, a drive to evaluate his opinions and abilities" and this has generated much interest in social psychology and most would agree the desire to learn about self through comparison through others is universal. There is also evidence that appears to suggest that virtually everyone engages in social comparison from time to time. The process and the information it generates are thought to have basic evolutionary benefits. Also noted by Gilbert P. et al. (1995) that the need to compare oneself with others is phylogenetically very old, biologically very powerful, and recognisable in many species. The primary goal of social comparison is to acquire information about the self. However the underlying motives for comparison that have been generally accepted are (Taylor et al. 1996; Wood 1989): self-evaluation, self-improvement, and self-enhancement.

As suggested by D.P. Gilbert et al. (1995) social comparison is spontaneous, effortless and unintentional and relatively automatic. Nonetheless it is also the case that circumstances and situations vary in the extent to which they promote the need for comparison-based information. In general, interest in social comparison is associated with uncertainty (Festinger 1954; Wills and Suls 1991), especially in the periods of stress, novelty or change. Brickman and Bulman (1977) noted there is some risk in comparison with others under threatening circumstances that can produce information that is unflattering to the self. However situations that foster competition are likely to promote interest in social comparison for most people, whereas performance-based situation will promote it for some (Ruble and Frey 1991). Research on classroom goal structures also indicate that cooperative learning techniques which give students a sense of relative competence vis-à-vis their peers can positively influence such diverse school outcomes as self-esteem, peer relations and academic achievement (Aronson and Osherow 1980; Johnson and Johnson 1978).

Studies have indicated that social comparison serves a variety of functions and that people alter their comparison strategies according to their current motivations (Taylor and Lobel 1989; Wood 1989; Wood and Taylor 1991). For instance, it is thought that people seek social comparison with worse-off others (downward comparison) when the concern for self-enhancement predominates (Friend and Gilbert 1973; Pyszczynski et al. 1985). Further they seek social comparison with better-off others (upward comparison) under conditions in which the desire for self-improvement prevails (Arrowood and Friend 1969; Suls and Tesch 2006; Wilson and Benner 1971). Similarly, it has been suggested that people seek comparison with worse-off others in response to esteem threats that do not lend themselves to instrumental action, whereas they seek upward comparison in response to threats that they can address (Buunk and Ybema 1997; Major et al. 1991). Hence this is an indication of strategic decisions by people because they expect different outcomes (self evaluation and performance) depending on their comparison strategies.

On the other hand, experiences (in learning and otherwise) in general can be considered as knowledge or skill gained through the observation or exposure to some phenomena or some events. When applying to learning it is the process, systematic or random, of exploring and active or passive cognitive engagement with a domain knowledge with the objectives of gaining skill and wisdom knowledge in the hope of fulfilling the Bloom's Taxonomy of educational objectives (Krathwohl 2002). There is also a fundamental difference between experiential learning and learning experience (LE) in an academic eLearning environment. In its simplest definition experiential learning is learning by doing whereas learning experience (LE) refers to successful peer learners' experience in an eLearning system, which can be harnessed by contemporaries through technology to

improve the effectiveness of learning in a domain knowledge.

In eLearning experience related knowledge is not just concerned with material that exists, the interactions with the technologies such as computers and Internet, but also related to many experiences that are human oriented. In his sociocultural theory, 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.

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 or the tacit knowledge. That is, knowledge of the type of information, when it is useful, what to do with it and how to reuse it. Implicit knowledge of learners, according to researchers (Nonaka 1994; Ronchetti and Saini 2004), reflects a learner's cognitive, behavioural and psychological learning pattern, which is in fact a form of tacit knowledge that can be used as feedback in many forms especially in social comparison to help improve the performance and the quality of learning. Thus we see a great value in sharing of learning experiences, and particularly using it for social comparison.

There are reports in literature on studies that have aimed to capture and analyse tacit knowledge in teaching and learning processes. Some researchers (Derntl and Mangler 2004; Derntl and Motschnig-Pitrik 2005) in their work tried to model the processes of blended learning as patterns and produce a web template based on social-technical and pattern-based approach. The authors argue that modelling such processes and artefacts of teaching and learning as patterns allows one to reuse successful didactic principles and improve the effectiveness of course design. In later work of Derntl and Calvo (2011) they ultimately produce and use an e-learning framework approach capable of enhancing the usability and usefulness of educational design patterns. In the work of Teo and Gay (2006), they use formal concept analysis to tap into and externalise expert's or mentor's tacit knowledge, a form of patterns of teaching, and use it in personalising eLearning system. Peter Dolog's (2008; 2004) research provides a framework and infrastructure of eLearning system that enables personalised access to distributed heterogeneous knowledge repositories. He addresses the key issues of choosing appropriate learning repositories with a vast number of federated learning offerings. Many of the existing works provide holistic framework and approach in designing personalised eLearning but do not address the issue of learning experience and patterns that could be detected directly to improve learning and teaching through feedback and recommendation. There are some works that identify the differences of learning patterns between learners using LMS statistics but not specifically using eLearning tool in a blended environment (Campbell et al. 2007; Coates 2005; Dawson 2010), which is the common practice in most teaching environments currently. Despite relative ease in extracting logging data for student online interaction, the visualization and aggregation of this data is lacking (Mazza and Dimitrova 2007; Mazza and Milani 2005). This results in limiting staff (and students) in understanding the linkage between student's online interactions and implementing pedagogical innovation.

Lastly, insights gained from externalizing various forms of tacit knowledge embedded in teaching and learning has to be shared somehow to create value. Providing a good and sensible recommendation system can increase the user's trust of the system (Santos and Boticario 2008; Swearingen and Sinha 2001) and therefore influence the attitude of users towards the system. We also use a form of recommendation in our work through the use of Kiviat charts as a visual feedback for students after each milestone to reflect their learning and providing a means of social comparison. We conducted an experiment with an existing eLearning tool in a blended environment running for an information systems course to collect user interaction data, the performance grades and the attendance (lectures and tutorials) data, and demonstrated how these can be used to improve quality of learning and performance outcomes.

FEEDBACK SYSTEM

The eLearning tool used in this study is called LDBM and is supported by a backend database or log that records all interactions with the tool. Prior studies (Morris et al. 2005) have indicated a strong relationship between engagement of eLearning component and students' academic performance in a blended learning environment. It has not only a direct impact in the performance outcomes of the learners but also has the effect of increasing the self-efficacy of students learning. The LDBM is designed to register an entry in its log only when students interact by submitting answers to questions, which in fact is a representation of cognition and learning process.

The logs captured by the LDBM are processed into percentage of engagement after each milestone for the practicals attempted in the LDBM for each student. The attendance for lectures and tutorials, and grades of students are also collected manually after each milestone is completed. These data are normalised and used for feedback visualisation in Kiviat diagram. The Kiviat diagram not only displays the performance metrics for individual student but also the class averages, as well as personalized recommendations. This process is visualized in Figure 1.

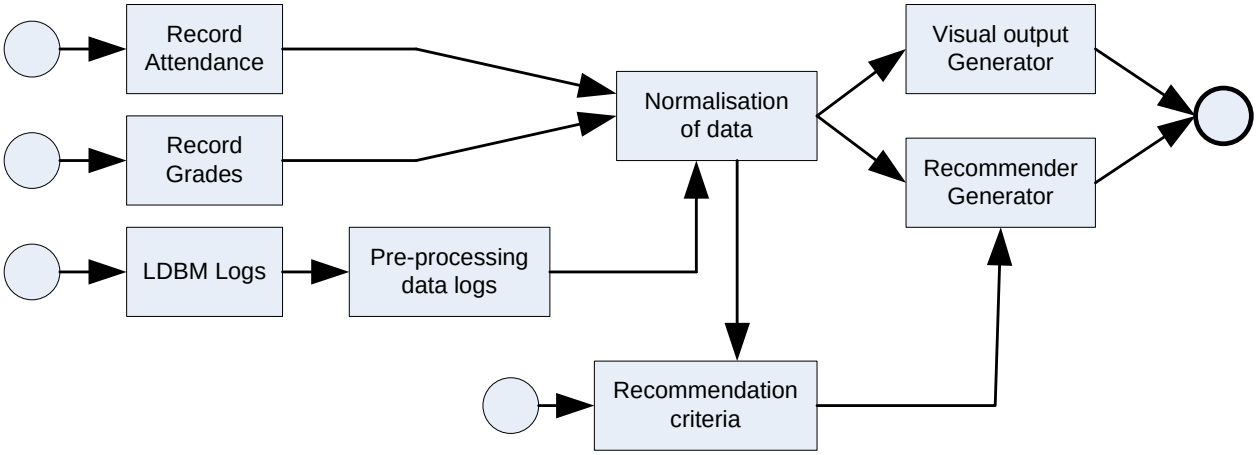
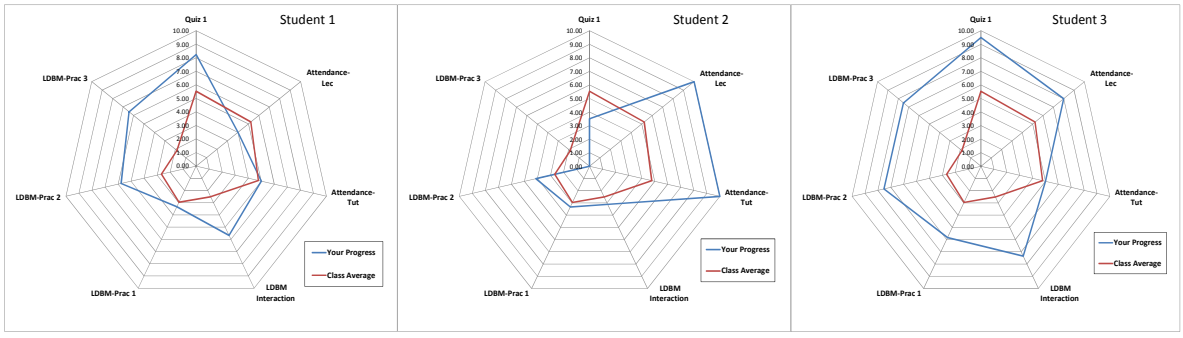


Figure 1: The process flow of generating visual output and recommendations

Kiviat chart has common application in the control of quality improvement to display the performance metrics of any ongoing program (Basu 2004). Kiviat charts are histograms arranged in a circular shape. Usually 5 to 8 spokes (which represent multitudes measured) are arranged in a wheel and intersect with imaginary cycles. The rim represents the maximum value of the magnitude. An intersection close to the rim indicates a large magnitude; close to the core indicates a small magnitude. Subsequently a glance at the shape of the Kiviat chart resulting from linking intersections in each spoke can quickly convey a great deal of information about the underlying metrics. Kiviat chart usually represents a static picture that is they do not have time axis, but represent an instantaneous state or a time-integrated state (summary). Hence we use Kiviat chart to assist in providing feedback and subsequently studying the impact of feedback instruments on changes in study patterns in general and eLearning interactions in specific.

The recommendation generator uses data from the normalised processed LDBM logs, grades and attendance records and based on pre-set criteria using "*if-then*" statement to make selection for recommendations to students. Typical output of the feedback system is presented in Figure 2.



Recommendations:

- **You are doing very well.**
- **You could improve further by working more on the online learning tool LDBM and attend more lecture sessions.**

Recommendations:

- **We suggest that completing all the practicals in LDBM could help improve your understanding and positively impact on your grade.**

Recommendations:

- **You are doing excellent! Keep up the good work.**

Figure 2: Kiviat charts with recommendations

METHODOLOGY

The study was carried out over 4 semesters of two years of studies, which involved 540 undergraduates, and postgraduate students of diverse backgrounds and disciplines who were taking the course "Introduction to Information Systems". The course consists of 3 hours lecture, 1 hour tutorial and 1 hour lab per week. Students

can make use of an eLearning tool to supplement their conventional mode of learning. The students are assessed through 2 quiz tests, 1 take home assignment and a final semester exam. Students are well informed of the benefits of using the tool at the beginning of the course especially towards the learning milestones. Students also exercise their own free will to use the eLearning tool LDBM at their own pace and time.

A few threshold topics within the course were carefully selected which were covered thoroughly in the eLearning tool, through a wide range of examples and large repository of practice questions. We took the scores of these topics at the respective quiz tests during the semester and again the scores at the final exams to measure performance improvement in the learning process.

The experiment consists of two phases and the first phase consists of 2 semesters in which students attended lectures and labs, and used the eLearning tool but without having the Kiviat chart feedback and recommendations.

In the second phase which also involved students in 2 semesters we have exactly the same setup but after each milestone the students were given a visual feedback with Kiviat chart each for their main learning metrics as well as serving as the means to compare with the class average. At the same time a recommendation is also generated for each of the student targeted at improving the quality of their learning. The Kiviat chart and the recommendations are updated and uploaded for the student immediately after each milestone when student check their results online.

We use the collected results of the students to run *paired t test* for the four semesters. In addition to that we also administered questionnaires in the last two semesters to do a qualitative assessment and to investigate student perceptions on the Kiviat charts and the recommendations. The results are tabulated in Table 1.

As shown in Figure 2 the Kiviat charts are uploaded during the learning period when students just completed their quiz1 milestone. It has 7 metrics with a mixed characteristic of the learning metrics to give a more accurate overall picture in a blended environment. In the example we have the attendances for lecture and tutorial, overall eLearning engagement to date, engagement of the different practicals for specific topics designed in the eLearning tool and the grades achieved so far, i.e. quiz1. The Kiviat chart also displays the class average. This allows the learners to compare and provides an opportunity for them to appropriately adjust their learning approach and behaviour based on the recommendation. Feedback is provided together with the Kiviat chart to impart the following into the students:

- Motivational: provides messages to motivate the learner when working in the course so he/she does not get frustrated if the results were lower than expected, e.g. “You are doing well and keep up the good work”.
- Learning Styles: suggest a way of learning the content which applies best to the particular student, e.g. “You could improve further by working more on the online learning tool LDBM and attend more lecture sessions”.
- Collaboration: fosters sharing contributions, communicating with course members etc., e.g. “We suggest you to meet up with your tutor to discuss topic 2”.
- Scrutablility: promotes self-reflection through the visualisation tool, and learning metrics.

RESULTS AND DISCUSSION

Quantitative Analysis

In the first phase of the 2 semesters where the Kiviat chart and recommendation feedback was not present, the tests for the pre-performance and post-performance do not show a statistically significant difference in the mean value of the scores. The first semester saw a degradation of the mean value from the pre to the post performance. There are many reasons that may be attributed to the degradations. For example, the time lag between the exams, the number of exams they had to deal with during the final exam period, a feeling of disconnect with the topics as it was already assessed etc. However, these are only possibilities, in actual fact all we can observe is that students did worse off in the final exam on the same questions as in the in-semester quiz. However in the second semester the mean value for the pre- and post-performance show an increase in the value although statistically insignificant.

In the second phase of the experiment the Kiviat chart and recommendation were introduced. The *paired t test* results shows that the mean value for the pre- and post-performance indicates statistical significant improvement in students’ performance. In semester 2 of 2011 and semester 1 of 2012, there was a statistical significant increase in the mean value from 0.617 to 0.665 with $p < 0.01$ and $t = -2.845$, and mean value of 0.563 to 0.606

with $p < 0.05$ and $t = -2.071$ respectively. The results are much in line with the theory of social comparison that seems to have two major benefits (Levine 1983). First is the self-evaluation in which comparison can provide information that is not obtainable in any other fashion. This is not only valuable for assessing current performance but even more importantly for allowing selection of future tasks that are within students' level of competence. Obtaining the self-evaluation of an ability that is known to be predictive of success in a specific domain is helpful in deciding whether to invest time and effort in the domain. Second, comparison information may be helpful in sustaining motivation. Regardless of one's level of performance the comparison agents can usually be identified and through explicit or implicit competition, can increase one's effort. We argue that the improvement in the performance at the end can be attributed to the value of social comparison and personalized recommendation that was presented to the learners through the Kiviat charts.

Table 1. Summary of results

				Std. Dev.		Mean			
Phase	Year	Semester	N	Pre	Post	Pre	Post	t	Sig. (2-tailed)
1	2010	1	126	0.240	0.210	0.627	0.610	0.853	.395
1	2010	2	125	0.183	0.251	0.648	0.688	-1.483	0.140
2	2011	2	123	0.207	0.247	0.617	0.665	-2.845**	0.005
2	2012	1	166	0.292	0.215	0.563	0.606	-2.071*	0.040

** Significant at the 0.01 level * Significant at the 0.05 level

Tesser and Campbell (1980) believe that the impact of social comparison information on a person's self-esteem is mediated by the relevancy of the underlying performance dimensions. Performing better or worse than another on a highly relevance dimension has greater impact on self-esteem than the same performance on a low-relevance dimension. Our dimensions chosen for comparisons are the metrics used in the Kiviat chart and they are directly relating to the main learning options available to the students, for example engagement with eLearning tools and the attendance in tutorials and lectures. A recent study (Au et al. 2011) indicates that eLearning engagement is highly correlated to the performance outcomes and therefore highly relevant in the process of learning.

We make a further observation regarding the upward comparison and downward comparison theories in influencing the choice on the performance levels or relevance dimensions (Blanton et al. 1999) to compare with. Upward comparison chooses to compare upwards results in improved performance mainly because of increase in motivation while seeing another person succeed and also observing another person's proficiency at a task can reveal useful information about how to improve. Downward comparison suggests that self-confidence can be enhanced through comparison with others who are thought to be worse off (Gibbons et al. 2002). In our case the immediate comparison that students get from the Kiviat chart is to compare with the class average and we believe that this would leverage the extreme comparisons between the very high and the very low achievers. Together with the recommendations aiming at encouraging and motivating the high achievers and further eliminate the feeling of inferiority for the low achievers, the system was able to project positive impact on the overall learning outcomes.

Qualitative Analysis

The respondents from the questionnaires collected from the second phase were 72 out of 289 students. Of the 72 students responded to the questionnaires, 19 students explicitly provided comments on the visual feedback and the recommendation systems in the open-ended question. The responses on the questionnaires were particularly positive with respect to their learning behaviour, strategy and the objectives. On closer observation on the responses, they could be grouped into 3 main categories: general opinions or *perceptions*, comments relating to *comparisons* and *adaptations* to learning strategy on the basis of the feedback. A selection of comments is presented in Table 2.

It is obvious from the responses that the social theory of comparison plays the most important role here as most of the comments are relating to students being able to compare themselves to the rest of the class and the visual feedback Kiviat chart was designed to include the class average for all the measured metrics. Comparing against the class average allows them to self-reflect and therefore gives them an idea where they stand and how they are

progressing overall. Together with the recommendations, this would also give them an idea of where their weaknesses are and how much time and effort they should invest in which element of the course. The impact on student behaviour and possible benefits emerging from it are highlighted in some of the comments in the category of *adaptations* in table 2. These are in line with the work by Levine (1983) that social comparison would undergo an important phase that generates responses that include cognition and feeling about one self and also overt behavior involving task performance and self-reward. From the excerpts we could see that the system encouraged them to try out the LDBM and they were able to pin point the general weaknesses of their learning, adapt their learning strategies, and eventually the overall performance of learning can be lifted. Finally, the *perceptions* category highlights the fact that the feedback had positive impact on students' sense of wellbeing, which is widely recognized as a factor that contributed to improving the quality of learning both in terms of outcomes, as well as experience and attitudes.

Table 2. Students' responses

Categories	Students' comments
Perceptions.	• Love the recommendation system. • Actual result data was useful but tutors forgot to collect attendance so tutorial data was off. • The system is useful and it's the first subject I've seen this information actually graphed. The functionality to graph the assignment should be added next time.
Comparisons.	• I thought this was a great feature of the course. It'd be great to see this across other subjects as it's great to see how you stack up against the rest of the class. Great work there, I thoroughly admired it. • It was useful especially to see averages. • It is an awesome way to get feedback, much better than just seeing a number result! • Very appreciate to provide this feedback. Definitely shows the progress of our works. • Give me an idea of how I went against the class. • It was good to know how I compared to the rest of the class. • It gives me an indication on how well I was doing in the comparison to the rest of the cohort. • Loved knowing where I stood.
Adaptation.	• It encourages me to give LDBM a try. • Very clear to know what I need to improve and compare with other students. • Give me right answer and how to solve problems.

With the Kiviat feedback system complemented with personalized recommendation, the system not only able to provide a means for students to self-reflect through the visualization but also able to provide motivational messages and recommending appropriate learning paths to assist students to improve their learning. The recommendation also promotes collaboration among the students-students and students-tutors for better communications.

CONCLUSION

In this paper we have presented a novel form of providing feedback and recommendation for learners in a blended learning environment. We conducted an experiment using the learners experience in the engagement of eLearning tools, the attendance of lectures and tutorials and the performance outcomes at specific milestones, as metrics for visual feedback and recommendations. We used inspiration from social comparison theory to provide comparative feedback to allow students to compare with the class average. Further through statistical *paired t test* and questionnaires to study the impact of the feedback system, our findings reveal that the feedback and recommendations enhance the quality of learning and improve the performance and experience outcomes of the students.

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