Learners' Access Patterns and Performance in an Online Course in Science, Technology and Society

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ABSTRACT

This study considers online courses as important patches in the distance education landscape, with each learner producing unique patterns of access to these patches as adaptive activities to the learning structure and processes inside the course site. Once analysed, these patterns will provide information that can help instructors create an adaptive feedback mechanism, customised learning activities and assessment, and a contextualised student support system.

A log file analysis technique was conducted to mine learning management system (LMS) logged data for learners' access patterns, and to analyse the relationships between access patterns and gender, and access patterns and performance. Four access pattern variables were analysed, namely: log in frequency (LoginFre), frequency of accessing the resource materials (ResFre), number of posts in the discussion forum (NoPost), and number of posts being read (FoRead). About 12,992 logged data of 70 learners in an online Science, Technology, and Society course were analysed. Descriptive and inferential statistical tests were conducted for pattern and relational analyses.

Learners' log in frequency ranged from 1 to 103 hits with distribution that is slightly normal. Their average hits on resource materials were estimated at 30 with 110 hits as maximum and 0 as minimum. Interestingly, the learners are more inclined to read the posts of their classmates than discussing their own thoughts in the discussion forums. This pattern is more revealing among female learners than in their male counterparts (p < 0.05). These patterns showed a strong significant positive relationship with learners' performance (p = 0.000), implying that learners' activities are crucial for effective online learning.

INTRODUCTION

Landscape ecology offers several concepts that might be useful in analysing certain elements of distance education (DE), given the heterogeneous and fragmented characteristics of its landscape. Heterogeneity is formed by its various administrative and academic components with unique structures and functions, while fragmentation results from the physical separation of these components. The various offices or centres (including those that exist in the web) of DE-providing institutions can be considered as "patches" that are spatially distributed both in the physical and virtual environments. In landscape ecology, patches are spatial units at the landscape scale (Forman and Godron 1981) whose spatial and temporal characteristics influence organisms' movement. There is evidence (e.g. Mcintyre and Wiens, 1999; Johnson et al., 1992; de Knegt, 2007) that organisms' movement in a patch are affected by the structure and dynamics of such a patch. These structures include the availability of resources, habitats, nests and the like. The presence or absence of these structures in a patch determines the pattern through which organisms interact with other organisms and with their environment. The specific patterns of movement are forms of organisms' adaptive mechanisms in their current habitat. The foraging movement of organisms, for instance, has been observed to be related to energy conservation behaviour where energy conserved is utilised for other physiological processes such as reproduction. MacArthur and Pianka (1966) formally developed a theoretical and empirical construct related to this movement, and they called it the Optimal Foraging Theory (OFT). According to OFT, organisms move in a manner that maximises their resource utilisation with the least energy expenditure.

In distance education, more specifically in online learning, course sites can be viewed as learning patches that exhibit virtual structures and processes, which may affect the way online learners and instructors engage in learning transactions. Just as in natural patches, course sites contain resources (e.g. learning materials, links to supplementary reading materials, messages in discussion forums, learning activities, etc.) that may affect the way learners access them. Several studies (e.g. Zaïane, 2002; Hijón-Neira and Velázquez-Iturbide, 2010; Rizzolo, Aden, and Stewart, 2002; Butrous, 2011) indicate that course site structure produces different access patterns, site utility and learning behaviour among online learners. For instance, Hijon and Velasquez (2006) in Hijón-Neira and Velázquez-Iturbide (2010) showed that the lack of navigational mechanism in the course site resulted in a long logged on time for online learners. As indicated in their study, the average connections to the site was over 30 minutes (Hijón-Neira and Velázquez-Iturbide, 2010), which might be reduced when the mechanism is present.

McIsaac et al (1999) in Hijón-Neira and Velázquez-Iturbide (2010) studied the interactions of doctoral students with an online environment. They observed that such interactions were goal-focused (McIsaac 1999 in Hijón-Neira and Velázquez-Iturbide, 2010). Hellwege et al. (1996) in Hijón-Neira and Velázquez-Iturbide (2010) observed a similar pattern with students' access in a geology website where they concluded that students were accessing resources according to their immediate needs. They access recent lecture notes posted in the course site in preparation for examinations. These findings highlight the need to analyse learners' access behaviour, and then, relate this to learners' performance in online courses.

Recently, the relationship between access patterns and student performance has become an interest among researchers (Butrous, 2011). Several researches have

shown strong positive relationships between access to any course site page and performance. For instance, Pitman, Gosper and Rich (1999) reported in their study in a geography course that access to the learning packages is significantly affecting students' performance. Learning packages page contains the learning materials, which include print and multimedia resources. Butrous (2011) also reveals that performance of students enrolled in a core unit within a master of business administration (MBA) programme differ significantly with varying frequencies of access in the communication, content and student areas in the course site. Furthermore, they indicated that a close examination of the significant differences in access patterns to the course window and its components reveals that there is a critical point that differentiates high achieving from low achieving students in the programme (Butrous, 2011). This critical point is important in providing online instructors the opportunity to introduce intervention strategies to improve the learning experience of all the students.

But analysing learning behaviour in electronic media is a complex activity given the physical separation between the learners and the instructors. "Without the informal monitoring that occurs in face-to-face teaching, it is difficult for educators to know how their students are using and responding to these environments" (Hijón-Neira and Velázquez-Iturbide, 2010). This situation requires the development of effective methods of determining and evaluating learners' behaviour in a virtual classroom. If instructors could dynamically and scientifically observe, monitor and track learners' online behaviours, they might be able to provide adaptive feedback, customised assessment and personalised attention as needed (Nanjiani, Kelly, & Kelly, 2002 in Hung & Zhang, 2008). Neuhauser (2002) in Hung & Zhang (2008) also indicates that with scientific methods to monitor learners' activities, online instructors may help students to establish patterns of successful learning activities.

Recently, several research methodologies (e.g. Hung & Zhang, 2008; Neuhauser, 2002; Nanjiani, Kelly, & Kelly, 2002; Butrous, 2011) such as data mining, log file analysis, clustering and the like were developed and tested to analyse access patterns and online learners' performance. The current study utilises log file analysis as a method of inquiry and analysis since it is more appropriate for the learning management system that is used by the course under investigation. Log file analysis involves retrieval, cleaning and analysing logged or stored data in servers. These data are called log files. Fansler & Riegle (2004) define log files as computer files that record an activity on a Web server. Every Web server has some systems of storing information about the users' identity, pages that are accessed, time and date of access, IP address used, and the number of bytes transferred. All this information is dumped into a log file that is stored in a specific location in the server (Fansler & Riegle, 2004). Once explored and analysed, these files can be a good source of information for instructors to track their students' online learning behaviour, which in turn, can help them evaluate the effectiveness of their instructional design (Fansler & Riegle, 2004).

OBJECTIVE

The study was conducted with log file analysis technique to analyse the access patterns of learners and relate these patterns with their performance in an online course in Science, Technology and Society (STS). The patterns were differentiated between male and female learners.

METHODOLOGY

The Virtual Learning Classroom

The study involved a three-unit course in STS as part of an undergraduate programme curriculum at the University of the Philippines Open University, Philippines. The course was offered for 16 weeks during the first semester of the 2010-2011 academic year. The learning material is divided into four units, which discuss the history and nature of science and technology, the social dimensions of science and technology, theoretical frameworks for critically evaluating science and technology, and the roles of science and technology in governance.

For each unit, there were unit objectives, reading materials and discussion forums. To encourage more participation and provide initial information about the course students' composition, the task for the first discussion forum was to introduce themselves to their fellow online learners. The other forums were devoted to the discussion on learners' understanding of the key concepts discussed in the course.

The course site was hosted in myportal.upou.edu.ph, which is powered by modular object-oriented dynamic learning environment (MOODLE). The homepage was divided into three sections, namely, course links, bulletin board, where course announcements were posted, and administrative menus (Figure 1).
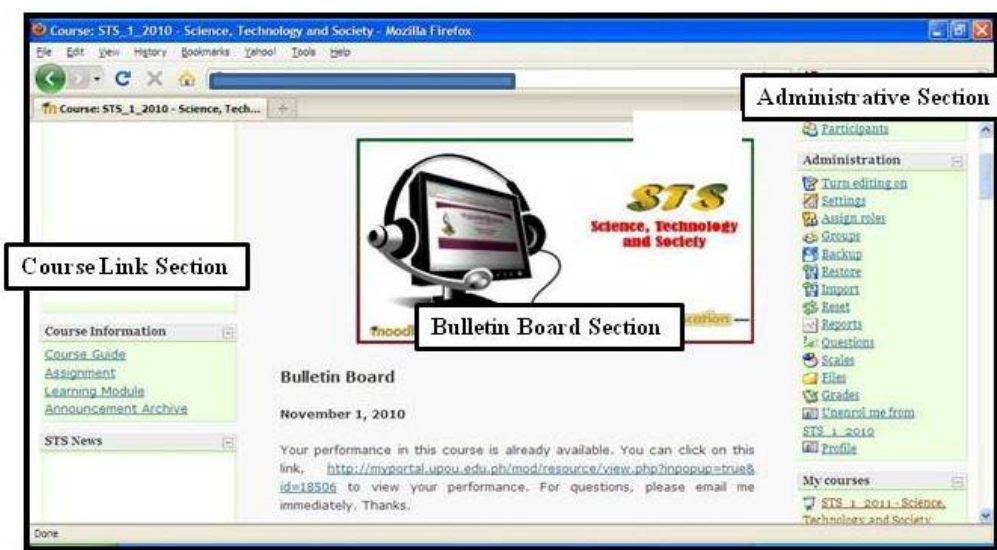

Figure 1: Structure of the course site in STS showing the various sections

Links to learning materials, discussion forums and information on course requirements and grading system are placed in the course link section. Instructions on how to navigate the course site, course updates, important course announcements and other important information on course activities are posted in the announcement section. List of enrolled participants and other course delivery tools are located in the administration menu section. The announcement section was purposely located at the mid-portion of the homepage to help the students see immediately what they need to do after logging

on in the course site. The site was available 24/7 to the students throughout the teaching period.

Students' Performance Assessment

The performance of the learners was measured through two written examinations, each of which consisted of three to five essay questions that either asked the students to explain a theory or apply a concept in a real-life situation. The coverage of the examination is as follows: the first examination covered topics discussed in units 1 and 2 of the learning material (e.g. What is science? What is technology? Why study science and technology vis-à-vis society; the scientific method and why science is a social product) and the supplemental readings for both units; the second examination covered the topics in units 3 and 4 (e.g. critical social theory; frameworks in analysing the relationships between technology and society; science-governance interplay, and science, policy and institutions). Each examination has a total score of 100. The passing score is 60.

Student Sample and Log File Description

Students who did not register in the course site and those who have extended (*ext*) grades were not included in the study. Log files of about 71 learners were mined and analysed for four access pattern variables: frequency of logging on in the course site (LoginFre), frequency of accessing the resource materials (ResFre), number of posts in the discussion forums (NoPost), and number of posts read (FoRead). Each student's log file consists of time and date of access, IP address, full name of the student, action done, and page visited or resource requested (Figure 2). These are automatically recorded in the student's profile in myportal.

Figure 2: A typical log file in the myportal.upou.edu.ph

Log File Analysis Procedure

The analysis of the learners' log files started with data retrieval from the students' profile from myportal.upou.edu.ph. A total of 12,992 files were retrieved and converted into Excel files. Aggregated values of the four variables were computed for each learner. Descriptive statistics such as means, standard deviation, percentages, skewness, minimum and maximum were computed by using the data analysis tool kit of Excel 2007 (Microsoft Office). Computed values were visualised by using graphical and tabular representations. Inferential statistics such as correlation and comparison of two independent means were computed to determine whether or not access patterns differ between gender and if they are related to students' performance.

RESULTS AND DISCUSSION

Learners' Access Patterns

Descriptive statistics of data collected from the learning management system are shown in Table 1. As indicated in Table 1, the distribution of log in frequency is close to a normal distribution. On the other hand, the distributions of resource materials access, number of posts and number of posts read are slightly skewed to the positive. These data and distributions revealed that the most common online activity of the learners was logging onto the course site. They also indicate that students tended to access the resource materials and read the posts more often than interacting with their peers and the instructor. Table 1 further shows that the number of posted messages (mean = 6. 87, SD = 4.53) is significantly ($p < 0.05$) less than the number of messages read (mean = 75.44, SD = 59.96), indicating that discussion forums are more important tools for disseminating ideas rather than a facility for interaction. Hung and Zhang (2008) observed similar patterns with online students in Taiwan.

Table 1: Descriptive Statistics of the Four Variables (n = 71)

Variable	Log in Frequency	Resource Materials Access Frequency	Number of Posts	Number of Posts Read
Mean	46.65	34.46	6.87	75.44
Standard Deviation	22.60	21.73	4.53	56.96
Median	43.50	28.50	6.00	65.00
Skewness	0.42	1.89	0.98	1.76
Minimum	2.00	5.00	0.00	5.00
Maximum	103.00	110.00	21.00	271.00

A 3D cluster graphical visualisation was generated to illustrate the relationship among the following variables: log in frequency, frequency of accessing the course materials and number of posts (Figure 3). A close examination of the graph reveals that there are groups of learners who have seldom visited the course site, accessed the materials, and posted a message in the discussion forum. It also reveals that students access the materials more often than interacting with their peers in the discussion forum, as indicated by more points leaning towards the y-axis (i.e. frequency of accessing the resource materials). Figure 4 also shows that learners tend to read the messages posted in the discussion forums more often than reading the resource materials uploaded in the course site. This is expected since they are provided with a print copy of the instructional module, and probably, they use it more often than the e-copy uploaded in the course site.
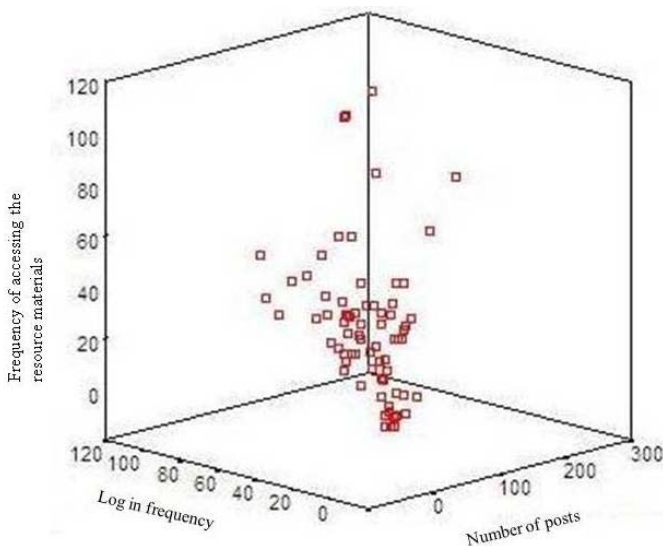

Figure 3: A 3D scatter plot showing the relationship between login frequency, access to the resource materials, and number of posts

Access Patterns by Gender

As Table 2 shows, both genders are equally represented in the sample though they differ in access patterns. As indicated in Table 2, log in frequency and access to resource materials of the male learners shows a slightly normal distribution but the distributions of the number of posts and posts read are skewed towards the positive. This is different from the patterns observed among female learners where the distributions of all variables are skewed towards the positive. In addition, individual log in frequencies and access to the resource materials are not affected by gender though male learners have lower computed mean for the latter.

There is however a significant difference in the number of posts ($p = 0.007$) and posts read ($p = 0.017$) between the genders. On average, each female learner has posted seven messages in the discussion forums, which is 71% more than the messages posted by male learners, and had read 78 messages, which is more than 60% of the messages read by male learners.
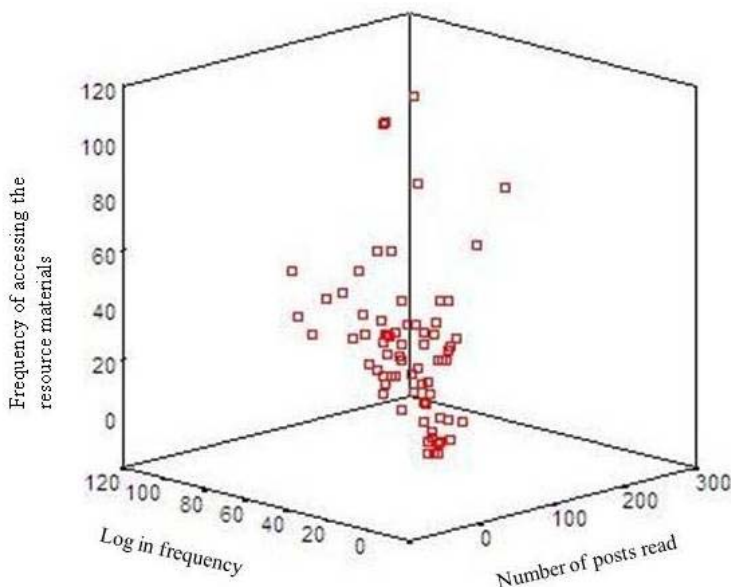
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Figure 4: A 3D scatter plot showing the relationship between login frequency, access to the resource materials, and number of posts read

The results indicate that female learners are more actively engaging in online discussions than their male counterparts. This pattern can probably be attributed to the preference of female learners to use an electronic medium for consensus building and communication with peers. According to Benbunan-Fich and Arbaugh (2006), women usually prefer to use an electronic medium in building consensus and engaging in conversation with peers. Data also supports "models of male separate and female connected learning styles" of Belenky et al (1986) and MacKeracher (1994) in Blum (1999). But Blum (1999) indicates more engaging male learners than females. To cite, males posted 9% more messages than female students (Blum, 1999).

Focusing on the gender difference in access patterns, a 3D plot (Figure 5) was generated to illustrate the relationship between log in frequency (LoginFre), number of messages posted (NoPost), and number of posts read (FoRead). The graph revealed that a small group of female learners had high number of messages posted and had read more messages than their male counterparts. However, most of the students' patterns were scattered towards the FoRead axis, again indicating that learners are more inclined to read than post messages.

Access Patterns and Students' Performance

Learners' scores in the examinations ranged from 25 to 90 with distribution slightly skewed to the negative. Females outperformed the male learners though the difference is not statistically significant ($p = 0.166$). Among the four variables tested for correlation, log in frequency and number of messages read have shown significant positive relationships with students' performance ($p = 0.008$, $r = 0.332$, and $p = 0.042$, $r = 0.239$, respectively). The data indicate that learners who have visited the course site and read

Table 2: Descriptive Statistics and Test of Significance of the Variables by Gender

Gender		Login Frequency	Frequency of Accessing the Resource Materials	Number of Posts	Number of Posts Read
Female	Mean	37.58	34.19	7.03	78.11
	N	36.00	36.00	36.00	36.00
	Std. Deviation	25.54	26.52	5.28	56.94
	Skewness	0.64	1.44	0.68	1.36
Male	Mean	38.57	25.37	4.11	47.49
	N	35.00	35.00	35.00	35.00
	Std. Deviation	25.55	15.00	3.39	48.49
	Skewness	0.13	0.49	0.90	2.91
p Value		0.87	0.09	0.007*	0.017*

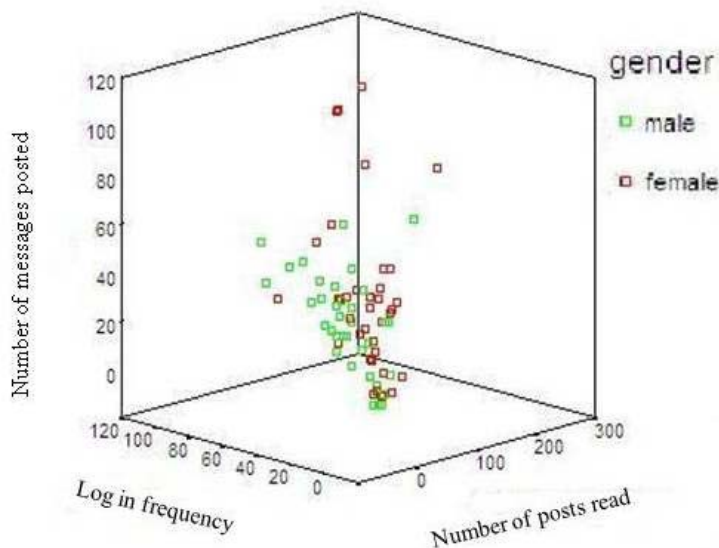* - significant at 95% confidence interval

Figure 5: A 3D scatter plot showing the relationship between login frequency, number of messages posted, and number of posts read by render

messages in the discussion forums more frequently were more likely to get higher scores in the examination. Butrous (2011) reported the same results. He observed that high achieving online learners have superior access to discussion boards and students' homepages than those who belong to the lowest achiever cluster. This highlights the importance of discussion forums as information sources, which can increase learners' knowledge of the subject matter. In addition, some research studies (e.g. Black, 2005; Thomas, 2002; Klemm, 2000) showed a consistent result that online discussion forums had promoted students' higher order thinking skills and an environment that increased the critical thinking skills of the students (Zhang et al 2007). According to Yildiz & Bichelmeyer (2003) in Zhang et al (2007), the reason for this result is that "asynchronous text-based communication provides participants more time to understand peers' ideas, think and create their own responses, and edit and revise their postings."

As indicated in Figure 6, learners who had visited the course site and read messages in the discussion forum more frequently performed better than those who have less frequently visited the course site and discussion forums. Davies and Graff (2005) in Yukselturk (2010) reported a similar observation when they studied the relationship between the level of online participation and student grades. They concluded that students achieving high or medium passing grades engaged more actively than students achieving low passing grades (Yukselturk, 2010). Picciano's (2002) study on the analysis of discussions in courses delivered completely online also indicates that students perceived greater quality and quantity of learning as a result of participating in the discussions.
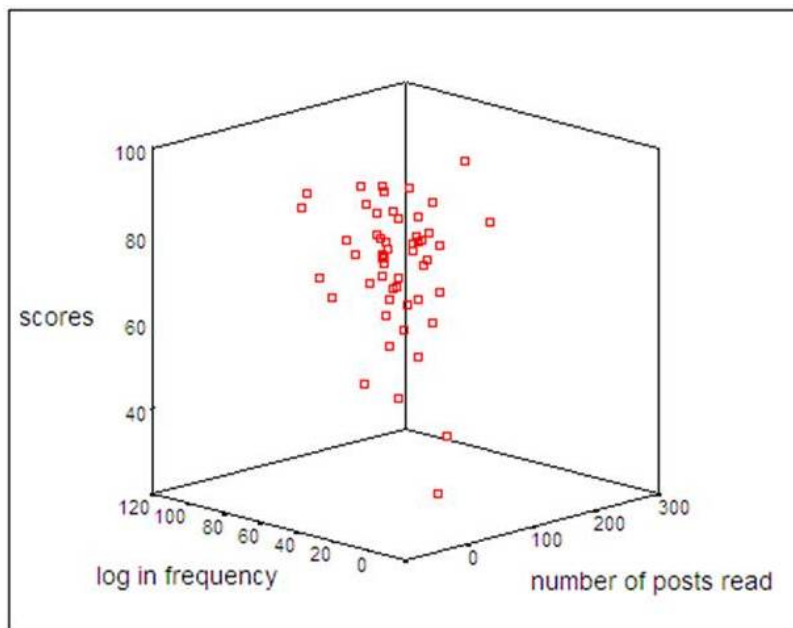

Figure 6: Relationship among login frequency, number of messages read, and students' performance

These findings and the data obtained through the study underscore the importance of establishing a more engaging and productive environment for online learning. Facilitation in learning transactions for students' understanding of critical concepts, principles and skills should be looked into by online instructors. This task should include motivating learners' knowledge-sharing and knowledge-building through interactive discussion and designing a variety of learning experiences (Liu et al 2005). The use of discussion forum as a main asynchronous communication tool among learners in this study emphasises its role in interactivity between learners and instructors, and among learners. The positive relationship between the number of messages read and learners' performance also indicates the importance of interactivity for a successful online learning experience. Interactivity reduces the sense of isolation, which affects the success of learners in online education. According to Wegerif (1998) in Freeman (nd), without a feeling of community, learners are on their own, likely to be defensive and unwilling to take the risks involved in learning. Thus, they are more likely to withdraw from the course. Ensuring communication and interactivity through asynchronous tools such as discussion forums therefore can help alleviate isolation by creating a social presence in the online learning environment (Gunawardena and Zitte, 1997 in Freeman, nd).

CONCLUSION

Log file analysis has facilitated the analysis of access patterns in the study. Just as patches in a distance education landscape, course sites record patterns of learners' access to their various elements e.g. discussion forums and resource materials. Four pattern variables (i.e. log in frequency, access to resource materials, number of posts and number of posts read) were used to describe learners' access patterns.

Descriptive and inferential statistical tests were conducted and results indicate that the most common online learning activity of the learners was logging on to the course site. The results also reveal that the most common used tool for getting information from the course site is the discussion forum rather than the uploaded resource materials.

Gender has no influence over the decision to log on to the course site and access resource materials but it is significantly affecting learners' decision to post and read messages in the discussion forums. As indicated by the results, female learners are more active in posting and reading messages in the forums than their male counterparts.

In addition, learners' patterns of logging on to the course site and reading messages in the discussion forums were observed to significantly contribute to their performance. Learners who have visited the site and read messages more frequently got higher scores in the examinations administered for the course.

These pattern analyses highlight the importance for online instructors to invest on establishing a more engaging and productive environment where learners can actively exchange their ideas and learn from each other. They may need also to invest more time and effort to motivate more male learners to engage in knowledge-sharing.

Lastly, since the study only involved learners in one undergraduate course, results may be limited to the context of the course, and thus, should be used with caution.

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