Mapping and Identifying Features of e-Learning Technology through Indexes and Metrics

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Abstract: People' s educational needs and requirements change. At the same time, educational technologies and tools also evolve. Therefore, contemporary educational methods are obliged to adapt to both. E-learning is the mode of learning which serves the former while exploits the latter. As e-learning capabilities are moving into the third decade of their implementation (Kulik et al., 1990), the necessity of thorough assessment is imminent. Moreover, the adoption to e-learning of assessment features which were successfully used by e-commerce is also a challenging issue. In this study, a novel approach is presented and put to test. The approach tries to utilize applicable features of e-commerce technology to e-learning in an effort to measure usage, user trends and knowledge affiliations. To the extent, some already tested indexes and metrics are used for the quantification of qualitative features of e-learning. These indexes and metrics contribute to the assessment of both educational content exposed by the educators and content usage by the learners. In this paper the identified features are classified. Finally, an experimental case scenario that took place in a Greek university e-learning platform is presented. From the revealed results there is evidence that these corresponding to features variables can be used for the measurement of reach, richness and information density of an e-learning platform system.

1 INTRODUCTION

The Internet is a relatively new technology, which has been ever changing society since its creation. The way people live their lives has changed and made a big adjustment to the Internet's features and capabilities. People use the Internet for finding information, conducting research, communication, and most importantly for learning. During the last few decades the world has observed an outstanding growth of Internet usage. According to Internet World Stats, on 30th November 2015 there were more than 3,3 billion Internet users (Internet World Stats, 2015) and this number is expected to increase in the next years.

The explosive increase of Internet users has also led to dramatic shifts in the way of conducting learning. From our daily lives to traditional learning, the Internet has profoundly impacted and changed the way we learn. E-Learning presents enormous opportunities for both teachers and learners in the world. While e-Learning has proliferated with the growth of the Internet, there have been insufficient empirical research efforts concerning its status and learner behavior over the Internet. There may be some valid factors to explain the learner' s adoption of e-Learning.

Since the current situation and needs of learner have changed and the modern Internet user is experienced, fastidious to offered services, considerate, and capable to be self-addressed, it is necessary to know well the Internet learner, to maintain feedback with the learner, which ensures that in the future, school which uses e-learning will attract learner participation and increase its efforts on the Internet (Lingyte et al., 2012). E-learning need to be interested in every moment of learner's behaviour: the manner of browsing website, the way of choosing the educational content, the time and reasons for closing the page in the process of learning, the way to load the website of the LMS etc. Online learners must have the opportunity to submit

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their questions, suggestions and complaints. There should be developed an interaction between the teacher and learner, which has to become operational as soon as the LMS learner-browser makes any of conscious action (comments, complains, asks a query, etc.).

Schools have to think and explain why we have so much interest in e-learning. These unique dimensions of e-learning technologies suggest new possibilities for teaching through a flexible set of personalized, interactive and rich messages are available for delivery to different audiences. E-learning technologies make it possible for teachers to know much more about learners and to be able to use this information more effectively than was ever true in the past. Online teachers can use this new information to develop new information, enhance their ability to support learners and segment the learners into subgroups, each receiving a different level of teaching according to their needs and capabilities.

Although e-commerce and e-learning have mayor differences in objectives, data and techniques (Romero and Ventura, 2010), there are also some similarities as web applications (Lee, 2010). Laudon and Traver (2014) propose eight unique features of e-commerce technology which we fully adopt and adapt in this paper.

This paper uses indexes and metrics which firstly proposed and used the authors in previous studies with the innovation that they quantify 3 of the features that Laudon and Traver proposed. The remainder of this paper is organized into the following four sections. The second section provides a brief review of the background theory. The third section describes the approach of the study. Then, we present the results of a case study and finally we discuss the analysis and the implications of our study with conclusions, followed by presenting limitations and future research directions.

2 BACKGROUND THEORY

The eight unique features of e-commerce technology (Laudon and Traver, 2014) would be proved useful and applicable to e-learning technology and challenge both traditional and e-learning. The eight unique features of to e-learning technology are depicted in figure 1.

2.1 Ubiquity

In traditional learning, a *learning place* is a physical

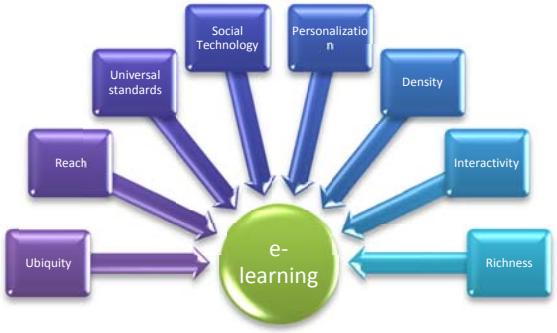

Figure 1: The unique features of e-learning technologies.

place we visit in order to learn. For example, a school typically motivates the learner to go someplace to learn. E-learning, in contrast, is characterized by its *ubiquity*; it is available just about everywhere, at all times. It liberates the learner from being restricted to a physical space and makes it possible to learn from the desktop, at home, at work, or even from car, using mobile e-learning. The result is called an *e-learning space*—a place extended beyond traditional boundaries and removed from a temporal and geographic location. From a learner point of view, ubiquity reduces *participation costs*—the costs of participating in learning process. To learn, it is no longer necessary that we spend time and money traveling to a school. At a broader level, the ubiquity of e-learning lowers the cognitive energy required to transact in a learning pace. *Cognitive energy* refers to the mental effort required to complete a task. Humans generally seek to reduce cognitive energy outlays (Shapiro and Varian, 1999).

2.2 Reach

E-learning technology permits learning independently of culture, region and nation and is more convenient and cost-effective than traditional learning. Internet makes much easier for online teachers within a single country to achieve a national audience than was ever possible in the past. The total number of learners an e-learning can obtain is a measure of its *reach* (Evans and Wurster, 1997). In contrast, most traditional learning is local or regional. In contrast to e-learning technology, older learning technologies do not easily cross national boundaries to a global audience.

2.3 Universal Standards

In contrast to most traditional learning technologies that differ from one nation to the next, the technical standards for conducting e-learning are universal standards and they are shared by all nations around the world. The universal technical standards of the Internet and e-learning greatly lower costs. Users of the Internet, both teachers and learners, also experience

network externalities—benefits that arise because everyone uses the same technology.

2.4 Social Technology: User Content Generation and Social Networking

E-learning technologies have evolved to be much more social by allowing learners to create and share content with a worldwide community. Social networks offers new forms of communication. All previous mass media in modern history, use a broadcast model (one-to-many) where content is created in a central location by experts. The Internet and e-learning technologies have the potential to invert this standard media model by giving learners the power to create and distribute content on a large scale, and permit users to program their own content consumption. The Internet provides a unique, many-to-many model of mass communication.

2.5 Personalization/Customization

E-learning technologies permit *personalization*: teachers can target their learning messages to specific individuals by adjusting the message to a learner's features. Today this is achieved in short time and followed by an instruction based on the learner's profile. The technology also permits *customization*—changing the delivered service based on a learner's preferences or prior behavior. Given the interactive nature of e-learning technology, much information about the learner can be gathered in the learning place at the moment of teaching. With the increase in information density, a great deal of information about the learner's past results and behavior can be stored and used by online educators. Personalization and customization allow educators to precisely identify learners' needs and adjust their messages accordingly.

2.6 Information Density

E-learning technologies increase information density both quantity and quality of information available to all learning participants, namely, learners and teachers. E-learning technologies reduce also information collection, storage, processing and communication costs. At the same time, these technologies increase the currency, accuracy, and timeliness of information making information more useful and important than ever.

2.7 Interactivity

Unlike any of the learning technologies of the twentieth century, e-learning technologies allow for interactivity, meaning they enable two-way communication between teacher and learner and among learners. In contrast, all of these activities are possible on an e-learning site and are now commonplace with smart phones and social networks.

2.8 Richness

Information *richness* refers to the complexity and content of a message (Evans and Wurster, 1999). The richness of e-learning makes them a powerful teaching environment. Prior to the development of the Web, there was a trade-off between richness and reach: the larger the audience reached, the less rich the message. The Internet has the potential for offering considerably more information richness than traditional media because it is interactive and can adjust the message to individual learners.

This theory that applies to ecommerce can also be used in e-learning with possible reductions.

3 APPROACH

The analysis of educational data may highlight useful information and support decision making regarding it (Romero and Ventura, 2010) . In the educational environment, it can help teachers and to analyze the learners' course activities and usage information to get a general view of a learner's activity.

The higher education student-evaluation data were analyzed in (Jin et al., 2009). The number of different pages browsed and total time spent browsing different pages were also presented in (Hwang et al., 2008). Pahl and Donnellan (2003) produce session statistics and discover session patterns. Zoubek and Burda (2009) analyzed mean values of attributes in data in order to measure mathematical skills. Gibbs and Rice (2003) use instructional web server logs to evaluate student behaviour with the number of visits, origin of visitors, number of hits, and patterns of use throughout various time periods.

Feng and Heffernan (2006) present that statistical analysis is very useful for assessing how many minutes the student has worked, how many problems s/he has resolved and his/her correct percentage and his/her performance level. Teachers prefer pedagogically oriented statistics such as overall success rate, typical misconceptions, percentage of exercises tackled and material read because it is easy to interpret. Teachers find the statistics from log data very unwieldy to inspect and very time-consuming to interpret (Zinn and Scheuer, 2006). However, statistical analysis of educational data (logs files/databases) can inform about where students enter and exit, the most popular pages, the browsers students tend to use and patterns of use over time (Ingram, 1999).

This study tries to quantify three of the unique features of e-learning technology with the aid of indexes and metrics. Indexes and metrics are used for the facilitation of the course usage assessment. Firstly, the indexes Sessions, Pages, Unique pages, Unique Pages per CourseID per Session (UPCS) are computed with the use of a Perl program. Then, the metrics Enrichment, Disappointment, Interest and Homogeneity are calculated. Some of these variables were presented in previous works of the authors (Valsamidis et al., 2010A; Valsamidis et al., 2010B; Valsamidis et al., 2012A) but none of these was mapped to any of the aforementioned features: Reach, Richness and Information density. With the measures of the table 1 and 2, we quantify the offered educational material to the learners in terms of input variables for each course. In the third column, we map the index/metric to the unique feature of e-learning that firstly proposed and used by Laudon and Traver (2014) in e-commerce.

Table 1: Indexes for courses.

Index name	Description	Feature
All Pages (AP)	The total number of pages per course created by instructors	Richness
Pages (P)	The number of pages per course viewed by users	Reach, Richness
Unique pages (UP)	The number of unique pages per course viewed by users. These pages are also called distinguished by course user pages	Reach, Richness
Unique Pages per Course and per Session (UPCS)	Number of Unique Visits per course viewed by users per session. It calculates course activity.	Reach
Files (F)	The total number of files in the course	Density
Size (S)	The total size of the existing files in the course	Density
Visits (V)	The total number of visits per course by all users	Reach
Duration (D)	The duration of (total) visits per course by all users	Reach

The number of sessions and the number of pages viewed by all users are counted for the calculation of course activity. Each session reflects when a user logs in to the platform and, after some activity, logs out from the platform. If there is no activity, there is a timeout of 30 seconds. The number of pages reflects how many pages were viewed by all users. There are some pages of the course which were viewed by many users but there were also some other pages not so popular. In order to refine the situation, we define another index which is called unique pages and measures the total number of unique pages visited per course viewed by all users. It counts each page of the course only once, independently of how many times they were viewed by the users. The Unique Pages per Course per Session (UPCS) index expresses the number of Unique Pages per Course visited in one Session; it is used for the calculation of the course activity in an objective manner. Because some novice users may navigate in a course and visit some pages of the course more than once, UPCS eliminates duplicate page visits, since it considers the visits of the same user in a session only once. The number of Unique Visits is the average number of unique pages viewed by users in visit intervals. The duration is the duration of (total) visits per course by all users.

The second category of variables is related to the courses' online educational content. More specifically the number of pages, the number of files and their corresponding sizes give an estimation of the content quantity, which is a crucial factor of online educational content. If the number of files and their size are small, this might be due to the weakness of the educator to upload enough educational content into the online platform. If the course has a lot of files with big sizes this could lead learners to face the cognitive overload problem and not study the course effectively.

The third category of variables helps researchers to discover learners' activity and follow up in a course. The number of sessions show how many times learners have logged in. This variable could be compared with number of visits and duration. The two later variables show if learners find course useful and like to visit its pages. If learners of a specific course visit more pages for a long time, this means that course content is interesting and useful for the learners. This could reflect the course quality. Consequently a good course in terms of quality may help learners at their study.

Table 2: Metrics for courses.

Metric name	Description	Feature
Enrichment (ENR)	(Unique Visits/Visits). Measures the number of times unique course information is identified by course users	Reach, Richness
Dissapointment (DIS)	Number of sessions per course over course visits. It reflects how often users discontinue viewing course pages	Reach
Interest (INT)	1-Dis	Reach
Homogeneity (HOM)	Homogeneity of unique visits per session (Unique Visits/Sessions). Characterizes the percentage of LMS course information independently discovered by each user participating in an LMS	Reach
Access (ACC)	The rate Upages/APages	Reach, Richness
Activity (ACT)	The rate Visits/APages	Reach, Richness
AFS	Average File Size	Density
VPS	Visits Per Session	Reach
VPD	Visits Per Duration	Reach

Enrichment is a metric which is proposed in order to express the "enrichment" of each course in terms of educational material. Enrichment is defined as the complement of the ratio of the unique pages over total number of course web pages as proposed in (Valsamidis et al., 2010b).

$$\text{Enrichment} = 1 - (\text{Unique Pages}/\text{Total Pages}) \quad (1)$$

where Unique Pages<=Total Pages.

Enrichment values are in the range [0, 1). When users follow unique paths in a course this is 0 while in a course with minimal unique pages this is close to 1. Since it offers a measure of how many unique pages were viewed by the users, it shows how much information included in each course is handed over to the end user inferring that the course contains rich educational material.

Disappointment is a metric which combines sessions and pages viewed by users and it measures the disappointment of the users in the course, in the sense that when a user views few pages of the course, s/he logs out of the course.

$$\text{Disappointment} = \text{Sessions}/\text{Total Pages} \quad (2)$$

In other words, the disappointment metric reflects how quickly the users discontinue viewing pages of the courses. Disappointment values are in the range (0, 1]. Due to the negative nature of the Disappointment metric, it was replaced by another metric which has a positive sounding manner, Interest. Interest metric is defined as the complement to the disappointment.

$$\text{Interest} = 1 - \text{Disappointment} \quad (3)$$

Both disappointment and interest metrics were proposed in (Valsamidis et al., 2010a).

Homogeneity metric is another metric, which is defined as the ratio of unique visited course pages to the number of sessions that visited the course.

$$\text{Homogeneity} = \text{Unique pages}/\text{Total Sessions} \quad (4)$$

where Total Sessions per course >> Unique course pages.

Homogeneity metric value ranges from [0,1), where 0 means that no user followed a unique path and 1 that every user followed unique paths. It is a course quality index and characterizes the percentage of course information discovered by each user participating in a course.

Access is a metric, which expresses the "richness" of each course in terms of educational content. Access is defined as the ratio of the unique pages over total number of course web pages (Gounopoulos et al., 2016).

$$\text{Access} = \text{Unique Pages}/\text{All Pages} \quad (5)$$

where Unique Pages≤All Pages.

Access metric values are in the range [0, 1]. When learners follow unique paths in a course this is 1, while in a course with minimal unique pages this is close to 0. Since it offers a measure of how many unique pages were viewed by the users, it shows how much information included in each course is handed over to the end user inferring that the course contains rich educational content.

Activity is a metric which combines visits and pages viewed by users and it measures the usage of the learners in the course, in the sense that when a user views few pages of the course, s/he logs out of the course (Gounopoulos et al., 2016).

$$\text{Activity} = \text{Visits}/\text{All Pages} \quad (6)$$

$$\text{VPS} = \text{Visits} / \text{Sessions} \quad (V/E) \quad (7)$$

$$\text{VPD} = \text{Visits} / \text{Duration} \quad (V/D) \quad (8)$$

These measures reflect users' behaviour related to the educational material (Valsamidis et al., 2012B).

$$\text{AFS} = \text{Size} / \text{Files} \quad (S/F) \quad (9)$$

The AFS reflects the contents of the courses in the e-learning platform.

4 CASE STUDY

In this section we present the results of applying the approach to the data collected from the E-learning platform during the first semester (spring semester) of 2016. The data refer to 24 different courses of the department of Accounting and Finance in TEI of East Macedonia and Thrace. The students are taught an average of 43 different subjects, each term starting with basic subjects on Business Organisation, Management, Mathematics, Accounting, Banking and Finance, Computing, Marketing, Economics, Special Accounting Issues, Tax Accounting, Auditing and ending with advanced subjects in various topics of Accounting and Finance. We chose the 24 courses that have the higher activity. More than 2000 students study in the department but they are not all active in the

Table 3: Measures of the indexes.

CID	AP	P	UP	UPCS	E	F	S	V	D
C01	22	456	20	273	304	12	750	25290	47745
C02	28	238	27	154	148	90	34575	29268	32592
C03	25	245	22	134	136	144	37383	279	348
C04	14	288	12	187	137	3	81	30273	43653
C05	29	434	27	238	192	12	363	5139	10986
C06	31	346	27	190	141	39	87870	4503	9852
C07	30	321	28	208	121	42	126831	4881	9555
C08	26	378	23	207	132	24	7413	2238	5193
C09	24	423	21	253	138	30	21594	2763	5736
C10	25	357	22	232	74	204	156954	5559	10905
C11	22	432	21	237	93	243	183639	4701	8673
C12	26	344	24	206	78	9	4065	2397	5250
C13	27	319	25	207	75	9	9495	2952	5982
C14	21	376	19	225	94	90	17829	19755	19713
C15	19	421	17	273	110	60	6195	7020	10758
C16	19	355	17	195	98	69	12525	813	2127
C17	17	430	16	258	126	6	2355	6264	10614
C18	18	342	16	222	106	6	20697	13695	22899
C19	9	317	8	174	105	18	1074	4056	8157
C20	14	374	12	224	133	24	1230	1779	3963
C21	16	419	15	272	182	78	6618	2814	5064
C22	25	353	23	211	141	9	324	9618	17118
C23	23	316	22	173	17	42	17088	6552	11280
C24	24	147	22	115	0	51	15405	13002	20334

e-learning platform. The institute offers traditional learning and the e-learning is a supplementary mode. The department uses the Open eClass e-learning platform (GUNet, 2016).

The measures of the indexes of the collected data are presented in table 3.

The measures of the metrics are presented in table 4.

Table 4: Measures of the metrics.

CID	Enr	Dis	Int	Hom	Acc	Act	AFS	VPS	VPD
C01	0.044	0.667	0.333	0.066	0.909	20.727	62.500	33.720	0.530
C02	0.113	0.622	0.378	0.182	0.964	8.500	384.167	0.847	0.898
C03	0.090	0.555	0.445	0.162	0.880	9.800	259.604	0.007	0.802
C04	0.042	0.476	0.524	0.088	0.857	20.571	27.000	373.741	0.693
C05	0.062	0.442	0.558	0.141	0.931	14.966	30.250	14.157	0.468
C06	0.078	0.408	0.592	0.191	0.871	11.161	2253.077	0.051	0.457
C07	0.087	0.377	0.623	0.231	0.933	10.700	3019.786	0.038	0.511
C08	0.061	0.349	0.651	0.174	0.885	14.538	308.875	0.302	0.431
C09	0.050	0.326	0.674	0.152	0.875	17.625	719.800	0.128	0.482
C10	0.062	0.207	0.793	0.297	0.880	14.280	769.382	0.035	0.510
C11	0.049	0.215	0.785	0.226	0.955	19.636	755.716	0.026	0.542
C12	0.070	0.227	0.773	0.308	0.923	13.231	451.667	0.590	0.457
C13	0.078	0.235	0.765	0.333	0.926	11.815	1055.000	0.311	0.493
C14	0.051	0.250	0.750	0.202	0.905	17.905	198.100	1.108	1.002
C15	0.040	0.261	0.739	0.155	0.895	22.158	103.250	1.133	0.653
C16	0.048	0.276	0.724	0.173	0.895	18.684	181.522	0.065	0.382
C17	0.037	0.293	0.707	0.127	0.941	25.294	392.500	2.660	0.590
C18	0.047	0.310	0.690	0.151	0.889	19.000	3449.500	0.662	0.598
C19	0.025	0.331	0.669	0.076	0.889	35.222	59.667	3.777	0.497
C20	0.032	0.356	0.644	0.090	0.857	26.714	51.250	1.446	0.449
C21	0.036	0.434	0.566	0.082	0.938	26.188	84.846	0.425	0.556
C22	0.065	0.399	0.601	0.163	0.920	14.120	36.000	29.685	0.562
C23	0.070	0.370	0.630	0.188	0.957	13.739	406.857	0.383	0.581
C24	0.150	0.340	0.660	0.440	0.917	6.125	302.059	0.844	0.639

The interpretation of the results, what we can learn from them, what the teachers do with them can and their relevance and usefulness are commented in the next section.

5 DISCUSSION AND CONCLUSIONS

The results present interesting findings in terms of reach, richness and information density.

The courses C06, C07, C05, C02 and C13 appear with remarkable high richness since they have the largest values in AP (the total number of pages per course created by instructors).

The courses C24, C02 and C03 appear with high richness and reach since they have the largest values in Enrichment. The courses C02, C23 and C11 appear with high richness and reach since they have the largest values in Access. The courses C19, C20 and C21 appear with high richness and reach since they have the largest values in Activity.

The courses C04, C02, C01, C14 and C18 appear with remarkable high reach since they have the largest values in visits. The courses C01, C04, C02, C18 and C24 appear with remarkable high reach since they have the largest values in duration. Courses C04, C02, C01 and C18 have high values in both indexes visits and duration.

The courses C14, C02 and C03 appear to have also high reach since they have the top values in VPD (visits per duration).

The courses C10, C11, C12, C13 and C14 appear with high reach since they have the largest values in Interest.

The courses C24, C13, C12, C10 and C07 appear with high reach since they have the largest values in Homogeneity.

The courses C06, C07 and C18 appear to have remarkable high information density since they have the largest values in AFS (Average File Size).

Teachers received the feedback regarding the results. They were asked to improve the quality and quantity of their course material. The position of a particular course in the ranking of courses would provide the motive for teachers to implement improvements in their educational content in order to be at the top of the rankings. Of course, many students study the educational content just before sitting their examinations. So, an excellent site with outstanding content maybe can be rarely visited. On the other hand, a poor website in terms of educational content may have frequent visits because visits are related to learners' expected grade.

Concluding, we presented an approach for measuring through indexes and metrics three of the features that Laudon and Traver (2014) proposed for use in e-commerce. We made the necessary mappings for the identification of reach, richness and information density, namely, three of the eight unique features. The percentage of the contribution of each variable for the measurement of the aforementioned features has to be defined after a thorough and repeative analysis.

However the limitations of the study are the sample size in terms of number of courses and number of students. The research was conducted in one school for one semester. Suggestions for further research are the repeat of study with new larger sample, to be applied in other Universities to confirm the findings of the study.

A twofold evaluation with research based on questionnaires both for students and teachers would be useful for confirming the findings of the study. However, this study is a starting point and offers a lot of food for discussion and further work.

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