SOM Clustering Technique to Identify Meaningful Learning in E-learning

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Abstract. Learning Management System (LMS) has been utilized broadly as a part of E-learning implementation for numerous institutions. This is because of the flexibility of LMS to convey the learning materials in different ways and approaches. One of the success factors of E-learning is concern with the interest shown by students towards E-learning. However, the common activities of current E-learning conducted by the students are limited to viewing and downloading learning materials. These two activities however, cannot be considered as meaningful learning that able to enhance learning quality. Because of that, this research intends to analyse student's usage based on meaningful learning characteristics by clustering the student's activities and actions during online learning. The meaningful learning characteristics that are associated with E-learning activities are active, constructive, intentional, authentic, and cooperative. In this regard, Kohonen SOM clustering method has been implemented to analyse the students' E-learning usage and to identify the cluster of student's meaningful characteristics. E-learning log file for 19 students taking Data Structure and Algorithm subject at Faculty of Computing, Universiti Teknologi Malaysia has been used for the analysis. Based on the SOM clustering result, the students has been clustered into 4 clusters. It is realized that the majority of the low cluster group have high access hits in the view actions for almost all activities but this is not the case in highest cluster group. Finally as for SOM clustering technique, it is realized that it is more suitable for this case study than other clustering methods that has been put to test in this research. The result from this research may assist lecturers to prepare a better strategy of designing E-learning components that able to deliver meaningful learning which are applicable to any course.

Keywords: Meaningful learning, E-learning activities, SOM Clustering

1 Introduction

The main issue of E-learning is that the activities that are carried out in E-learning by the students are not significant, even though there are various materials provided in E-learning. This is due to the E-learning usage among students is more prone to viewing and downloading materials. In this regard, even though E-learning has more to offer, it is not being used to full extent. Until now, it has been made clear that those activities are not considered as meaningful learning because it does not enhance the learning quality [1]. Meaningful learning characteristics are defined as those which are active, authentic, cooperative, collaborative, and intentional [2]. These characteristics will be associated with E-learning activities and actions.

This research intends to investigate SOM performance in clusters student's activities to interpret meaningful learning in E-learning. Many researches have been done previously, but the results are not found to show the analysis regarding the students' cognitive behaviour in their online course. Therefore, this research proposes a clustering method to examine the students' E-learning usage based on meaningful learning characteristics. The purpose of this study is to cluster students into different groups of meaningful E-learning usage so that by this analysis students and lecturers are able to determine whether meaningful online learning has been accomplished successfully.

This paper is organized as follows: In Section 1, we present the introduction of this paper. Then, in Section 2, we discuss more details of some related works. While in Section 3, we describe the overview of the research methodology that used in this research. Next, we provide the experimental results in Section 4. In section 5, we analyse the results from the research conducted. Finally, Section 6 states the conclusion of this research.

2 Related Work

Meaningful learning has been defined for conventional learning in the classroom. Yet, by the inclusion of learning environments which are not limited in the classroom, meaningful learning is helpful to reveal learning personalization [3-5]. Meaningful learning happens when complex ideas and information are merged with students' own experiences and prior knowledge to form personal and unique understandings [6]. Based on the concept of meaningful learning, the instructors should be able to develop the cognitive potential of students through appropriate learning activities. Many researchers have identified meaningful learning characteristics as being those which are active, constructive, authentic, and cooperative [7]. Later research extended these characteristics, to include guided-emotionally [8], integrated [9], and intentional [10]. These proposed meaningful learning characteristics are used as benchmarks for analysis of e-learning effectiveness [11]. In this paper, we use five meaningful learning characteristics as suggested by Howland et al., namely active, constructive, intentional, authentic, and cooperative [12]. The definitions of the characteristics in the student's perspective are as follows:

i. **Active**: When students effectively partake in the learning process by cooperating with peers and instructor. The instructor executes as the facilitator and gives the learning environment exercises that include students talking through learning, modifying what they learned and showing what they encountered.

ii. **Constructive**: When students At the point when students build information through investigation, reflection, and commitment inside the learning environment to accomplish a full interpretation of this knowledge. They grow new developments and thoughts through their new learning [13].The instructor's part is to plan the instructional system to be useful that empower students to assess elective answers for issues as a mean of testing and mirroring their comprehension.

iii. **Intentional**: When students are self-persuaded and effectively express their learning objective. They will think and take in more to satisfy a few objectives [14]. They are responsible for their own particular learning and powerfully screen their own advancement amid their study. They may ready to use innovations to represent and show signs of improvement justifiable about new learning that they have built.

iv. **Authentic**: When lecturers exhibit genuine issues and testing learning tasks and give learning situations that offer master thinking and access to various levels of ability.

v. **Cooperative**: When students work together and help each other to take care of issues and accomplish understanding. They convey and cooperate inside their gathering. To dodge inclinations, the instructor orchestrates the students in heterogeneous groups, in sizes of two to a few individuals, with the goal they should take care of an issue.

Yunianta *et al*., [15] have successfully mapped the meaningful learning characteristics identified above with the students' activities of E-learning as shown in Table 1. A value of "1" means that the activity has some relation with the meaningful learning characteristics. A value "0" means that there is no relation between the activity and the meaningful learning characteristics. These findings are valuable in order to identify which activities have good impact on meaningful learning. To the sum of all the entries for an activity determines the proposed weight for each e-learning activity in relation to the meaningful learning characteristics. With this key information, identifying meaningful learning in this course with SOM algorithm.

In addition to that, Octavian et al, have grouped the Moodle E-learning actions into three categories: (1) creating new data or information; (2) updating data/information for improvements; and (3) viewing or deleting data/information. Weights are assigned to these actions by category i.e. "3" for creating, "2" for updating/improving and "1" for viewing. Table 2 shows the proposed weights by Octavian et al.[1] of the E-learning actions based on the meaningful learning characteristics. These weights are used in this research to normalize the data log meaningful learning characteristics of E-learning usage before it can be used in SOM algorithm.

Table 1. The Proposed Weights for Meaningful Activities [15]

List	Activities	Active	Constructive	Intentional	Cooperative	Authentic	Weight
1	Blog	1	1	1	1	1	5
2	Discussion Forum	1	1	1	1	1	5
3	Lams	1	1	1	1	1	5
4	Wiki	1	1	1	1	0	5
5	Chat	1	1	1	1	0	4
6	Glossary	1	1	1	1	0	4
7	Workshop	1	1	1	0	0	4
8	Quiz	1	1	1	0	0	3
9	Assignment	1	1	1	0	0	3
10	Feedback	1	1	1	0	0	3
11	Journal	1	1	1	0	0	3
12	Notes	1	1	1	0	0	3
13	Choice	1	1	1	0	0	3
14	Survey	0	1	1	0	0	2
15	Course	0	0	1	0	0	1
16	Resource	0	0	1	0	0	1
17	Upload	0	0	1	0	0	1
18	User	0	0	1	0	0	1
19	Calendar	0	0	0	0	0	0
21	Label	0	0	0	0	0	0
22	Role	0	0	0	0	0	0

Table 2. The Proposed Weights for Meaningful Action [1]

			Actions Weight					
			Weight 3		Weight 2		Weight 1	
			Student	Instructor	Student	Instructor	Student	Instructor
Activities Weight	5	Blog Forum Lams Wiki	Add discussion Add post Subscribe Subscribe all	Add post Subscribe Subscribe all Assign	Subscribe Continue Attempt Submit Update post	Delete mod Search Prune post Continue attempt	View User report View discussion View forum	Report log View Report online User report
	4	Chat Glossary Workshop	Upload Start Complete	Upload Manual Grading	Edit Choose again	Submit Edit section Update	Mark read View View all	Mark read Preview
	3	Quiz Assignment Feedback Journal Notes Choice	Attempt Talk Link Add entry Update entry	Talk Link Choose		Edit question	Review Repost Info Enrol Delete Delete discussion	Info Close attempt Delete attempt
	2	Survey	Choose				Delete post	
	1	Course Resource Upload User					Close attempt	

3 Methodology

Figure 1 shows the four phase's research methodology conducted in this research which are the background study, data preparation and pre-processing, implement SOM clustering technique, and obtain and compare result with other clustering technique. The objective of the first phase is to get an overview and understanding of the

current issue in E-learning. In the second phase, activities are carried out to focus on the secondary data in order can be utilized in the next phase later. The third phase is where the implementation of data mining technique occurs in order to analyse the meaningful learning in E-learning. In final phase, the results will be evaluated and compared to other data mining technique in order to validate.

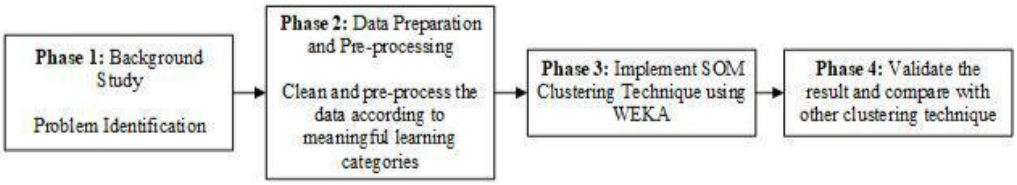


Figure-1. Research Methodology

4 Experimental Results

The data set used for this study is extracted from UTM Moodle E-learning environment log data file for 14 weeks learning sessions. The data contain the sum of the hits for each student based on the number of attributes. There are 6 attributes which contain 8006 datasets to be analysed among 19 students. WEKA is used as a simulation tool that embedded data from Moodle and interpreted the result using SOM clustering. In addition, the data extract are from the module view course, view assignment, submit assignment, view forum, add forum and view resource only. Figure 2 shows that number of students in that has been clustered into 4 clusters by the SOM algorithm in WEKA from the normalized data log.

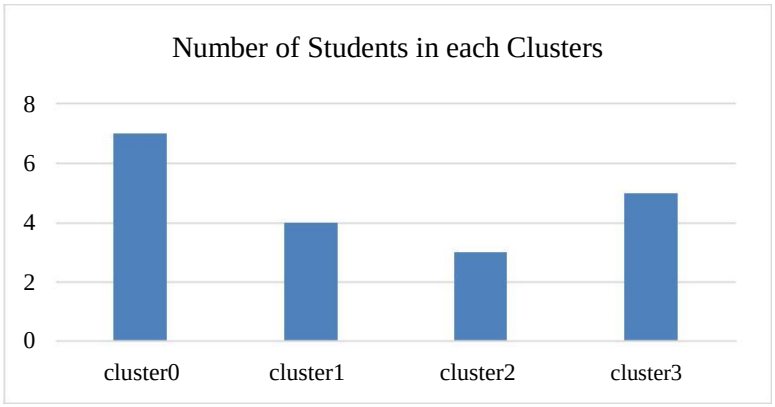
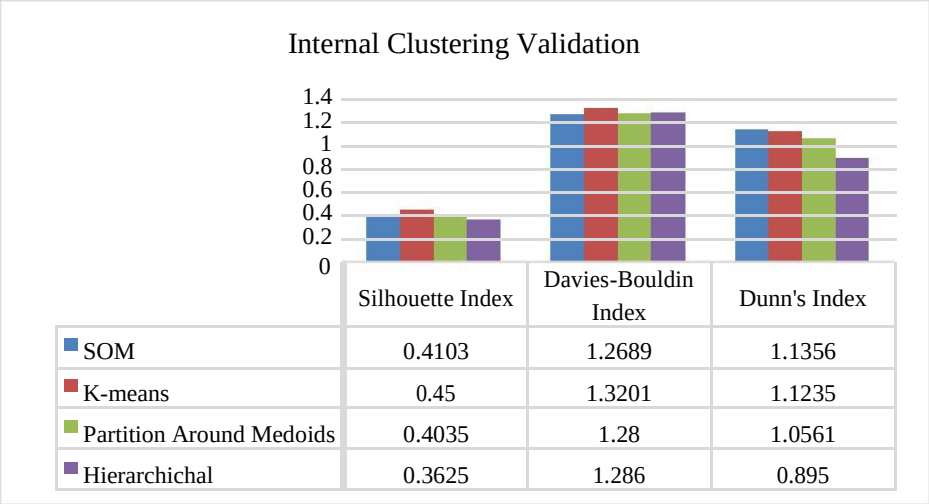


Figure-2. Number of Students in Each Clusters

5 Discussion

From the SOM clustering analysis based on 4 clusters, we can clearly see that each clusters represents different level of meaningful learning based on Figure 2. The cluster definitions are as follows:

i. **Cluster0**: Cluster group has low score for E-learning usage of meaningful activities and actions represents low level of meaningful learning.
ii. **Cluster1**: Cluster group has moderate score for E-learning usage of meaningful activities and actions represents moderate level of meaningful learning.
iii. **Cluster2**: Cluster group has moderately high score for E-learning usage of meaningful activities and actions represents moderately high level of meaningful learning.
iv. **Cluster3**: Cluster group has high score for E-learning usage of meaningful activities and actions represents High level of meaningful learning.



	Silhouette Index	Davies-Bouldin Index	Dunn's Index
SOM	0.4103	1.2689	1.1356
K-means	0.45	1.3201	1.1235
Partition Around Medoids	0.4035	1.28	1.0561
Hierarchichal	0.3625	1.286	0.895

Figure-3 Comparison of Internal Evaluation with Different Clustering Algorithm

Figure 3 shows the comparison of internal validation with different clustering algorithm. The clustering algorithms are compare with the same 4-partitioning group. From the result, SOM clustering algorithm gives better result compared to others algorithm with higher value of Dunn's Index and Silhouette index, lower value for Davies-Bouldin index. Thus, this proves that SOM clustering algorithm is the best algorithm to produce a good cluster structure. Each clusters by SOM algorithm, can identify the level of meaningful online learning that involves in each clusters which helps in this research rather vast.

6 Conclusion

This research applies a particular cluster method to observe students E-learning usage. The principle objective is to cluster the students usage of activities and actions in E-learning based on meaningful learning characteristics. The clustering result shows only a small number of students have successfully applied meaningful activities and actions in the E-learning system.

These online activities bring students to do high order thinking, collaborative, constructive and problem-solving tasks through online activities and eventually lecturers could perform assessment based on discussion result. This experiment result can guide lecturers to encourage more interaction with and between students during online learning, and to select activities, which are more active and collaborative in designing the learning strategies. SOM is very helpful in visualization the patterns that are hidden in the log data file and transformed it in very useful information for future student's performance. These findings shows that applied data mining technique to investigate students' online learning performance being meaningful result, because it is able to engage learning pedagogy where in this case meaningful learning characteristics and gives meaning to the E-learning log file by showing the usage of cluster based on this teaching.

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