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STUDENT BEHAVIOR ANALYSIS USING SELF-ORGANIZING MAP CLUSTERING TECHNIQUE

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ABSTRACT

E-learning is the resulting product from the evolution of internet technology. It acts as a medium of learning virtually without limitation of time and space and the need for teachers to be present physically. Currently, Moodle which is a learning management system has become an important medium to deliver e-learning easily by providing customized tool for educators to deploy learning materials in various forms, provide online discussion forum, online quizzes, online assignments and online activities among students. Moodle capture the student's interactions and activities while learning on-line using the log files. The data stored in the log files contain meaningful information such as the student's behavior, preferences and knowledge level. This information is very useful for educators to analyze the student's characteristics in order to improve the teaching methods. In addition, the student's progress can be improved by overcome the problem of one-size-fits-all and also to improve student learning experienced while using the system. In this paper, the student's action and behavior while using e-learning system are analyzed in order to identify the significant pattern of the student's behavior using Self-Organizing Map (SOM) clustering technique. The ability of SOM to analyze large amounts of data with variety types of variables and with better visualization of the result give an advantage to this technique. The experiment shows that unsupervised learning using SOM is able to identify several clusters from the student's behavior by visualization of high dimensional data into two-dimensional (2-D) space.

Keywords: student's behavior, log file, clustering, Self-Organizing Map (SOM).

INTRODUCTION

Nowadays, the evolution of the internet has changed the phenomenon in an education field. Students face the new learning experiences by using learning management system (LMS) as a medium to improve the teaching and learning process. Currently, due to the limitation of learning in the traditional classroom caused LMS to be used as a primary platform for teaching and learning process [1, 2]. Therefore, the changes in the learning environment from a traditional learning environment to computer based and web-based learning environment give benefit in the education field so that learning can be done at any place and time.

Web-based learning has become the primary medium for teaching and learning in university level. Most of the universities have their own learning management system that manages all the learning materials for learning purposes to be used by educators and learners. LMS is used to manage the learning material in education institution [3] and Moodle which is an acronym for Modular Object-Oriented Dynamic Learning Environment is the most famous leading LMS to deliver learning materials and to create effective online courses [4]. Moodle is an open source software that can be used globally and give flexibility to the educators to personalize the content of learning environment themselves [5].

The learning management system has large database storage to record all the activities that run in the system and able to produce basic reporting tool to extract the useful information from the log files [6]. However, LMS does not have a specific function that can give useful knowledge discovery about the data recorded in the system's log files and hence, it is challenging to analyze the data manually. Due to the complexity in extracting meaningful information from the log files, data mining will be used to avoid missing and misleading information from the data used. Self-organizing map (SOM) [7] is chosen as a mining technique in order to analyze and cluster the students' behavior that have been captured from the log data file. In this study, SOM is used as unsupervised neural network algorithm to perform the clustering process of the data recorded and maps them to two-dimensional (2-D) space for better visualization of the result.

This paper consists of the literature review conducted in this study, the research methodology used in conducting the study followed by the elaboration of the result and discussion of the experiment. The paper ends with the conclusion of the findings from the experiment.

LITERATURE REVIEW

The advancement in e-learning technology has given the opportunity to enrich the learning and teaching process in various ways. In the 1990s, education using technology started to be the trend in order to meet pedagogical goals during learning [8]. Learning management systems such as Blackboard, Sakai and Moodle [3] are widely used in order to manage the learning process and administration in an education institution. Recently, Moodle has become the leading open-source learning management system that is commonly used for teaching and learning [4, 8]. Moodle has been used worldwide to support both online teaching and online learning, grant free licensing and is highly

flexible for educators to deliver the learning materials. The flexibility comes from variety of Moodle features that help educators in deliver the learning materials such as forums, glossaries, wikis, assignments, quizzes and chats. Educators can also focus on pedagogical approaches that consider student's learning styles when deliver the learning materials [5].

Researches in e-learning technologies that explore teaching and learning activities in Moodle platform have become the attraction lately [9–13]. In online learning, there are huge amount of data produced by users every time they interact with the e-learning system [14]. The concept of learning anytime and anywhere enable the students to freely access the learning system without informal monitoring from the educators [15, 16]. Each learning management system has their own database that store the information of the system itself, user's personal information and the user interaction that occur while using the system [17,18]. The data recorded in the system's log file may contain some valuable and useful information that may be hidden in the database. That information captured in the log file can be used for improving the learning and teaching process in various aspects. However, the reporting tool in the learning system does not contain a specific function that can give an explanation about the pattern on learning behavior of the student while browsing the system. It is also very challenging to analyze the data manually.

Educational Data Mining (EDM) involve the techniques such as statistics, visualization, classification, clustering and association rule mining in learning management system [18]. Educational Data Mining Community describes educational data mining as an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods for the students' better understanding in the settings which they learn in [19]. EDM help to improve teaching and learning process in many aspects such as observing students' response on the course, suggesting suitable learning materials for different students, analyzing the time students spend on each page, examining student's online learning behavior, customizing the course, etc. [4, 16, 20]. Meanwhile, [21] has define data mining as a process for knowledge discovery in database that automatically analyze and provide model to discover some interesting unknown pattern from a large dataset. Thus, data mining has been used as an analytical approach to analyze the data in order to extract some knowledge information that is very useful to improve teaching and learning process in e-learning environment [22–27].

To date, SOM has been widely used in various areas such as tumor classification [28], motor rotor fault detection [29], industry, finance, natural sciences, linguistics, massive textual database [30] and bioinformatics data [31], but least in educational data. In educational field, SOM has been used in mapping web-based communities [32], predict student's performance [33, 34] and being applied in massive volume of educational data from university to extract the knowledge and pattern inside [34]. The results derived from mining using SOM technique are very significant either in classification, clustering or prediction.

Table-1 lists several educational mining researches focusing on the mining techniques used by previous researchers in order to improve the learning and teaching process. Researcher [35] used student's navigation, answers during the quiz session and others captured from the log file to match them with the learning style. From the table, most of researches used data from forum and exercise module to identify the student's learning style and not many focuses on the browsing behavior of the learning content prepared by lecturer. However, the uses of data from log data file from learning management system is still narrow in identify the student learning style.

Other than that researcher [36] use K-Means clustering to group the student based on their actively using attribute assignment and forum only. Expectation-maximization algorithm is implemented by [37] to group the students according to their performance in Moodle. The small numbers of researches that use SOM for clustering using the log file have encouraged this study to explore the performance of SOM in order to find the most significant clustering result that able to discover some hidden pattern in student's browsing activities in LMS.

Table-1. Data mining techniques used by the previous researcher.

Researchers	Data Mining Techniques	Data Observed	Research Purposes
Kularbphettong and Tongsiri (2012) [4]	Classification - Association Rules	Exercise, test, time spend, quizzes, students' grade and assignment	Analyze student's motivation behavior level (very low, low, medium, high and very high.)
Hogo (2010) [26]	Clustering and prediction- Fuzzy C- Means and Kernelized Fuzzy C-Means	Course material, number of hits, document-downloads, lab assignments and discussion board.	Classified the learner based on learner's profile. (regular, workers, casual, bad, and absent)
Merelo-guervós et al. (2004) [32]	Clustering - SOM	Hyperlinks	Group blogs for mapping web-based communities
Pratiyush and Manu (2015) [33]	Clustering (SOM) and pattern recognition	Class Performance, sessional and attendance	Clustering and monitoring student's academic performance (poor)

Researchers	Data Mining Techniques	Data Observed	Research Purposes
Livieris, Drakopoulou, and Pintelas (2012) [34]	Prediction- artificial neural network	Not stated in the paper	Predicting the students' performance at the final examinations. (Weak students)
Abdullah et al. (2015) [36]	Classification- Classification rules	Quiz, forum, sample code, animation, exercise, text, power point, video, examples, exercise, navigation and outlines	Comparing student's learning style based on student behavior with learning style (Felder and Silverman model)
Yusob et al. (2004) [37]	Classification- Kohonen's Self-Organizing Map (SOM)	Learning time, number of backtracking, number of getting help function and score	Identify learner's status (beginner, intermediate, advanced)
Cha et al. (2006) [38]	Classification- Decision Tree	58 attributes is used such as time spent, quiz, the number of button clicks and so on	Diagnose learner's preferences by using learner's behavior patterns in different learning style (Felder and Silverman model)
Graf and Liu (2008) [39]	Classification- Simple Rule-Based mechanism	Number of visits, time spent on the forum, exercises, self-assessment, tests, content objects, outlines, and the course overview page	Automatic student modeling approach for identifying learning styles (Felder and Silverman model)
Dung and Florea (2012) [40]	Prediction- Literature-based method	Time spent on each learning object, self- assessment exercises and others	Estimate students' learning styles automatically. (Felder and Silverman model)
Olama et al. (2014) [41]	Prediction-Multi-Layered and Feed-Forward Perceptron Model	Homework, quizzes, discussions and forum	Predicting student outcomes (Success or failure)
M. I. (2012) [42]	Classification(Decision Tree), Clustering(K-Means) and Association Rule mining algorithms(FP-growth)	Assignments, quizzes and forum	To predict students' final outcome (fail or pass)
El-Halees (2009) [43]	clustering Expectation-Maximization Algorithm (EM-clustering)	personal records and academic records of students, course records results of students' grades	Extracted knowledge that describes students' behavior to group students according to their performance. (Excellent, very good, good, poor and failure)

EXPERIMENTAL SETUP

The dataset used in this study was obtained from UTM Moodle E-learning log data file. The history of student's action is collected from Data Structure and Algorithm subject with the course code SCSJ2013 from semester 1, 2014/2015 session. There were 19 undergraduate students from Computer Science course involved in this study. The recorded data observed are from week 1 until week 14 of the semester where the teaching and learning process occur. There are about 8503 raw data recorded from this session. The log data were downloaded from the E-learning system in the excel format.

Figure-1 shows a sample view captured from Moodle E-learning system.to download the data log file. While downloading the data, there are several choices of download, such as to download the data for all students, all days and all the actions recorded in the log file history. This experiment focus on the ability of SOM clustering technique to cluster the student based on their similarity in the hits of their actions in e-learning. Due to the flexibility of SOM in producing better visualization of the result, this study use SOM to visualize patterns discovered from the clustered group of student's hits.

The next section describes the preprocessing steps for collected data that is important step before SOM clustering is applied. And it is describe how the data being process for clustering.

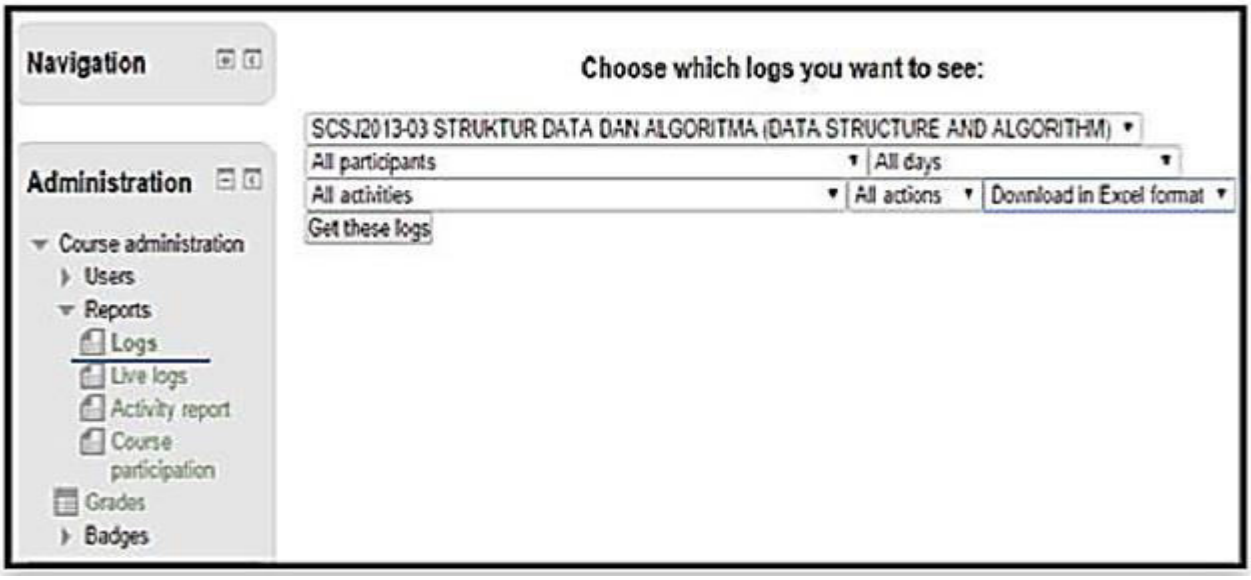

Figure-1. A Sample view to download E-learning log file.

Data pre-processing

Figure-2 shows a sample of the data collected from the log file. The log file data contain the information such as course, time, IP address, user ID, action and information for each student. Before the data can be mined, the data need to be cleaned to remove any noise and any data that are not related to this study. Log data file capture the action of all users interacts with the system which contains not only the student's information but also the information of the educators and the administrators. Log data file also contains the history of user activities while accessing the learning modules provided in Moodle such as assignment, forum, resources and other modules.

3	Course	Time	IP addres	User ID	Actio	Information
4	SCSJ201	####	10.60.84.1	stud1	assig	Submission statement accepted by user stud1
5	SCSJ201	####	10.60.87.2	stud1	assig	Submission status: Submitted for grading. The r
6	SCSJ201	####	10.60.84.1	stud1	assig	Submission status: Submitted for grading. The r
7	SCSJ201	####	10.60.84.1	stud1	assig	Submission status: Submitted for grading. The r
8	SCSJ201	####	10.60.100	stud1	assig	Submission status: Submitted for grading. The r
9	SCSJ201	####	10.60.84.1	stud1	assig	Submission status: Submitted for grading. The r
10	SCSJ201	####	10.60.84.1	stud1	assig	Submission status: Draft (not submitted). The nu
11	SCSJ201	####	10.60.86.1	stud1	assig	Submission status: Submitted for grading. The r
12	SCSJ201	####	10.60.98.3	stud1	assig	Submission status: Submitted for grading. The r
13	SCSJ201	####	10.60.98.3	stud1	assig	Submission status: Submitted for grading. The r
14	SCSJ201	####	10.60.85.6	stud1	assig	Submission status: Submitted for grading. The r
15	SCSJ201	####	10.60.84.2	stud1	assig	Submission status: Submitted for grading. The r
16	SCSJ201	####	10.60.84.1	stud1	assig	Submission status: Submitted for grading. The r

Figure-2. A sample view of the information stored in the log data file.

After the cleaning and filtering process, the remaining data that is used for SOM clustering are 2356 hits of student's actions. Therefore, the data is prepared by creating categories of action for 14 weeks and the learning process as depicted in Table-2.

SOM Clustering

SOM clustering is unsupervised learning that analyze browsing behavior patterns to form the clustered group. In this study, Waikato Environment for Knowledge Analysis (WEKA) is used as data mining tools which are free software available under the GNU General Public License and developed at University of Waikato [44]. The data is prepared in ARFF format and need to be normalized before the data can be feed in SOM.

SOM is a type of Artificial Neural Network (ANN) introduced by [7], which is a competitive learning algorithm to convert the high-dimensional input to low-dimensional space. SOM clustering is applied on the hits in each module from the data log file.

Table-2. Attributes filtered from E-learning.

Module	Variable	Action	Explanation
Course	courseV	Course View	Contains the information of the subject, resource display on learning environment
Assign	assignV	Assignment View	Allow to view the information about the assignment
	assignS	Assignment Submit	Allow student to submit the works as requested
Resource	asgI	Assignment Individual	Allow student to view and download the assignment materials and works individually
	asgG	Assignment By Group	Allow student to view and download the assignment materials and work by group
	Exe	Exercises	Allow student to view and download the exercise for certain topics
	P_exam	Test Materials	Allow student to view and download the test materials for examination preparation
	Notes	Notes	Allow student to view and download notes for each topic
	Example	Example	Allow student to view and download example for certain topic

The advantages of this method are based on implementation of simplicity, execution speed and a shorter training process using an unsupervised learning [45]. Figure-3 shows the process of SOM clustering algorithm in WEKA based on the [46].

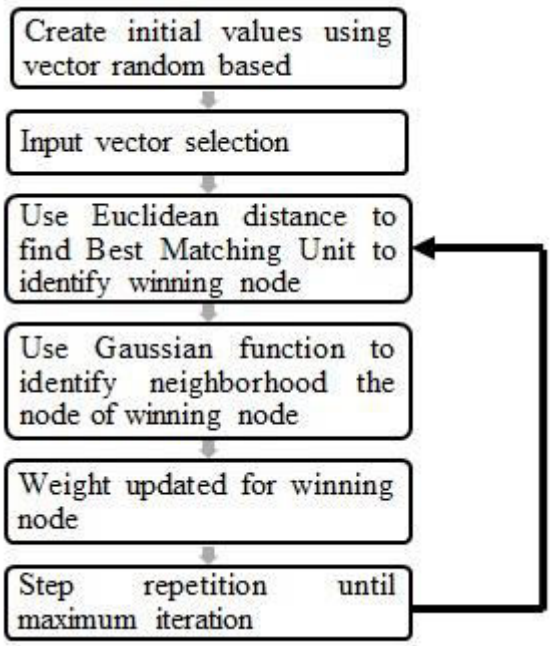

Figure-3. SOM Algorithm.

RESULTS AND DISCUSSION

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 and number of weeks. There are 14 weeks with 126 attributes which contain 2394 datasets to be analyzed. WEKA is used as a simulation tool that embedded data from Moodle and interpreted the result using SOM clustering. By using the attributes mentioned in Table-2 SOM visualize the student's browsing behavior in one semester. In addition, the data extract are from the module course, assignment and resource only.

Table-3 shows the sample of cluster analysis for week 1 of semester I 2014/2015. It contains the mean value of hits for student's browsing behavior. In the table, value 0 shows that there are no hit or similarities for the attributes in the cluster among the students. This is because in week 1 there are not many assignments to be submitted and no examination or quiz to be done, since in week 1 more on the fundamental of the subject. Furthermore, the non-zero values show the similarity in the clustered group for that particular attributes. The result also shows that students in cluster 3 have not browsing the example given in Moodle compared to other clusters.

Table-3. Sample cluster analysis for week 1.

Attribute	Cluster0	Cluster1	Cluster 2	Cluster3
courseV1	0.1744	0.1272	0.661	0.2788
assignV1	0.1272	0.3258	0.3991	0.3597
assignS1	0.11	0.3719	0.3993	0.3333
asgI1	0	0	0	0
asgG1	0	0	0	0
Exe1	0.11	0.1633	0.266	0.33
P_exam1	0	0	0	0
Notes1	0.4697	0.2907	0.6308	0.3875
Example1	0.0508	0.0586	0.2466	0

Furthermore, based on the cluster analysis, from the data in week 1 to week 14 there are four clusters from 19 students data set which are 3 students in cluster0, 8 students in cluster1, 5 students in cluster2 and 3 students in cluster3 as shown in Figure-4. The clustering result is based on unsupervised learning, so the clustered group is based on the similarity of student's browsing behavior without grouping the student. Besides, Figure-4 also

displays the percentage of hits of student's browsing behavior actions for each cluster. It shows that, for the whole semester, students in cluster 2 actively browsing the materials by 72% hit from 126 attributes. Followed by cluster1 (70%), cluster3 (64%) and lastly cluster0 (57%).

Although cluster1 have the highest number of students compared to others, but as shown in Figure-5 cluster2 have a high value of similarities for browsing behavior in most of the attribute for 14 weeks. For example, students in cluster2 likes browsing and downloading the example from the resource, do more in course view for the subject and active in assignment module compared to others. The data used for the Figure-5 is the value for cluster analysis for 14 weeks. Example's attribute shows the highest value and it shows that student tried to enhancing their understanding by downloading more on example prepared in the learning material. Lastly, it shows that each cluster group has the different pattern of browsing the resource material in the E-learning environment. 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.

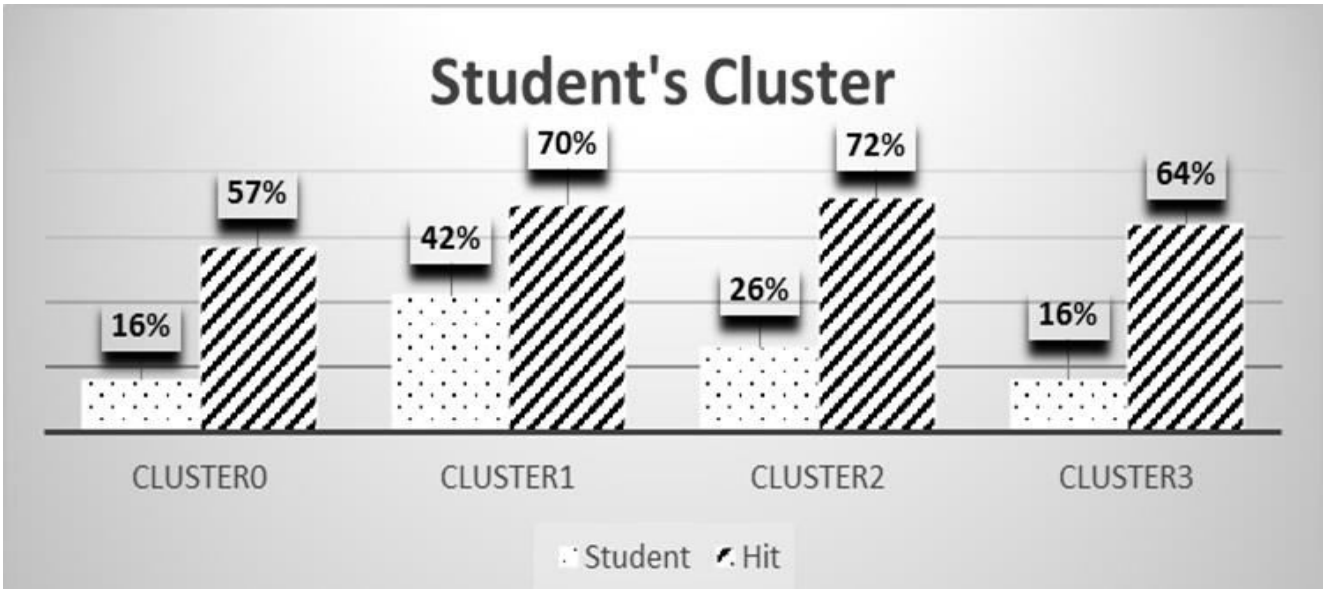

Figure-4. Student's cluster based on SOM clustering.

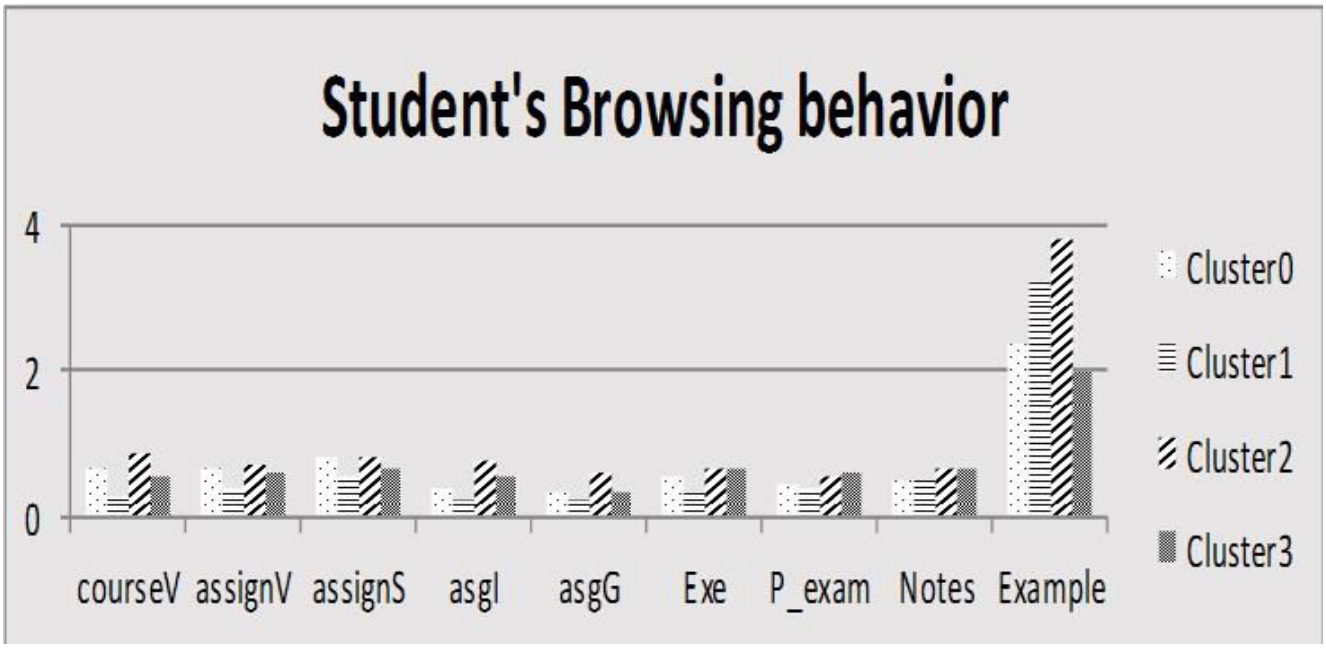

Figure-5. Student's cluster based on browsing behavior throughout one semester.

CONCLUSIONS

This paper explores on how students' browsing behavior captured in log file were clustered using SOM techniques. The browsing behavior being analyzed is from E-learning environment for one semester. SOM give great visualization in clustering for unsupervised learning. Besides, the process of data mining takes place in minimum amount of time when conducting experiments. The result shows well on how the pattern of student's browsing behavior is formed. Students in cluster2 show the active browsing behavior in certain attributes compared to others. They are eager to use the learning material prepared in the learning environment from the start of the learning process until the end of the formal weeks for teaching and learning in class. Due to various type of input, SOM can be very helpful in visualizing the cluster group. Finally, for future works, this research would like to explore more on how relation for student's browsing behavior with student's learning style and knowledge level for future adaptation in adaptive E-learning environment framework and explore more on SOM clustering using GPULib for big data of education data.

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