Clustering of Slow Learners Behavior for Discovery of Optimal Patterns of Learning

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***Abstract*—with the increased rates of the slow learners (SL) enrolled in schools nowadays; the schools realized that the traditional academic curriculum is inadequate. Some schools have developed a special curricula that are particularly suited a slow learner while others are focusing their efforts on the devising of better and more effective methods and techniques in teaching. In the other hand, knowledge discovery and data mining techniques certainly can help to understand more about these students and their educational behaviors. This paper discusses the clustering of elementary school slow learner students behavior for the discovery of optimal learning patterns that enhance their learning capabilities. The development stages of an integrated E-Learning and mining system are briefed. The results show that after applying the clustering algorithms Expectation maximization and K-Mean on the slow learner's data, a reduced set of five optimal patterns list (RSWG, RWSG, RWGS, GRSW, and SGWR) is reached. Actually, the students followed these five patterns reached grads higher than 75%. Therefore, the proposed system is significant for slow learners, teachers and schools.**

Keywords—Data mining; E-learning; Slow Learners

I. INTRODUCTION

A child may be a slow learner for various reasons, including: heredity, inadequate brain development due to lack of stimulation, low motivation, attention problems, behavior problems, different cultural background from that which dominates in the school, or distracting personal problems[1-4]. With so many slow learners remaining in school nowadays, the schools are beginning to realize that they make special provision for such students. The traditional academic curriculum of past years is now judged inadequate. Some have developed special curricula that are particularly suited a slow learners and their needs. Some schools, rather than developing special curricula are focusing their attention on the devising of better and more effective methods and techniques for use in teaching the regular curricula to slow learners [5]. Other schools work on both directions [6].

Knowledge discovery is an evolving interdisciplinary field that is connected to a number of research areas containing intelligent and adaptive web-based educational systems, intelligent tutoring systems, adaptive hypermedia, online courses mining systems and more others [7, 8]. Recently, its applications especially in the educational E-learning environments have been improved in order to cluster and mine the characteristics and the records of the learners to predict their studying results [9-11]. Also, it can find out helpful information that can be utilized informative estimation to aid educators to establish an educational basis for decisions when modifying and designing approach or teaching environment. Actually, in the educational systems, the data mining application is a repeated cycle of testing, refinement and hypothesis formation [7]. Therefore, the educational knowledge discovery and data mining techniques certainly can help through the discovery of hidden valuable knowledge to understand more about slow learner students and their educational behaviors.

This paper discusses the discovery of the optimal pattern of learning for elementary school slow learner students through applying two machine learning clustering algorithms Expectation maximization and K-Mean. The development stages of the proposed integrated E-Learning and mining system are briefed, where it goes through the development of digital contents of the English course with a mapping of these digital materials with environmental background of these students. Then the Skelton of the database with a simplified graphical user interface suitable for these slow learners is briefly presented. The rest of the paper is organized as follow; section 2 presents literature review and related. Section 3; go through the slow learner students definition, characteristics, suitable strategies of teaching and recommendation. Traditional teaching versus E-learning teaching is in Section 4. Section 5, presents machine learning clustering algorithms. Section 6 discusses the proposed clustering based integrated system based on three main levels, these are bottom, middle and top. Section 7, concludes the paper.

II. LITERATURE RELATED WORK

Data mining is supported by hosting models or tasks that capture the characteristics of data in several different ways such as: classification, clustering and visualization and other models. Many studies tried to enhance the results of implementing data mining approaches through e-learning systems [7-11]. But still there is an urgent need for considering the learning environment's design in order to utilize the chance provided by the internet. E-environment is not just a conversion from print-based material to digital one.

TABLE I. LITERATURES OF DIFFERENT DATA MINING TASKS IN EDUCATIONAL E-LEARNING

Classification		
Author	***Objective***	***Results***
Kangaiammal et. al (2013)	Classifying the user learning activities during the learning process depending on a continuous evaluation test for recognizing the understanding level.	Using a Rough Set Approach, they could increase teacher ability of awareness of the user learning ability before preparing the content of the course.
Marijana et. al (2009)	Creating adaptive courses for e-learning depend on the style of learning utilizing the intelligence tools	The students accomplished good results & high satisfaction's while attended the adapted courses based on learning styles.
Aski & Torshizi (2009)	To compare and investigate the results of the perceptions of four classification tools to analyze and classify the information of learner.	It is discovered that tools which use the Simple Bayesian or Decision Tree Algorithms had more truthful outcomes and helpful means in classifying the learner's information.
Furkan (2008)	To classify examination performances of three intelligence artificial favorite tools ANFIS, SVM, and ANN among environment that depends on E-Learning)	The system of Adaptive-Network-Based Fuzzy Inference (ANFIS) achieved better performances than Support Vector Machine (SVM) and Artificial Neural Network (ANN).
Clustering		
Mamcencko et. al (2011)	To analyze the data of the electronic examination.	The association rules and clustering aid in defining the relationship and patterns in the data of electronic exam. Also enhanced the system of E-examination by descriptive model.
Anitha & Krishnan (2011)	Build a model to link the E-learners at their early stages of learning by presenting navigation recommendation	They combined the clustering task with (AR) technique to achieve their goals. Their results showed that the usage of the patterns of clustered access decreased the size of data set and enhanced the accuracy of recommendation
Dominguez, et. al (2010)	To presents a method where the student current & past data is utilized live to produce hints for students that are ending the exercises of programming during the online competition	Association's rules- clustering and numerical analysis helped them discovering that the users who are given hints achieved higher marks than the users who were not.
Carmona et al. (2010)	To present the subgroup discovery techniques' application to the E- learning data from the Learning Management System (LMS) of the universities of Andalusia.	Optimization-Evolutionary algorithms were used for reducing a group of comprehensible rules that were obtained (due to their usage of the linguistic labels as well as their tiny size) that make them more explanatory for the instructor as well as getting the same values in the other measures of quality.
Liu (2009)	To generate the characteristics of learners from his data.	Achieved the behavior description of learner throughout dynamically generated metric and measurements.
Visualization		
Prema & Prakasam (2013)	Increasing the quality of the content in the learning materials as well as enhancing the concepts of self –learning for the students, and increasing their examination performance	It is indicated that there is a positive results for the usage of Data mining based e-learning system on the quality of learning and teaching.
Hung & Saba (2012)	To suggest a generic model for Educational Data Ming (EDM) examined by the existed model of the data mining and EDM literature.	The case study displayed the relationships & patterns that are exposed from the model of EDM that could be applied. The specific mining techniques of education help in improving pedagogical decision making and instructional design.
Kazanidis Et. al, (2009)	To suggest a platform that depends on the framework for recording, analyzing and processing data from Learning Management Systems (LMS)	The benefits of the usage of the frame work utilized the tools of data mining (DM) for the evaluation of the users and the content, suggesting new metrics and indexes to be utilized with the algorithms of DM, and to be adaptable to any LMS.

Table 1 abstracts some of these tries categorized by different mining task. These papers focuses generally on educational data mining model with different categories but certainly, they helped us reaching the results of this paper. Actually, Table 1, innovated the idea of our study which cover the effects of e-learning systems on the slow learners.

III. SL: CHARACTERISTICS & RECOMMENDATIONS

A child may be a slow learner for various reasons, including: heredity, inadequate brain development due to lack of stimulation, low motivation, attention problems, behavior problems, different cultural background from that which dominates in the school, or distracting personal problems[1-4]. The slow learning is not a learning disability or diagnostic category. It means that these students suffer from low rate of understanding for the materials; therefore, they need special education strategies. The slow learner is those students that when you are setting up the lesson, they cannot find his or her materials (book, pencils, Papers), when you remind him about the last lesson, he or she doesn't seem to remember anything. Table 2, list some of slow learners characteristics, teaching strategies and recommendation.

TABLE II. ABSTRACTION OF SL CHARACTERISTICS, TEACHING STRATEGIES AND RECOMMENDATION

Characteristics [17,28]	
• Scores low rates on evaluation tests • Their classification below average ability • Functioning ability is below grade level • prefers playing with younger children • Faces difficulty in following multi-step directions • Frequently has impaired fine motor coordination such as delayed ability to tie shoe laces	• Has few internal strategies (i.e. organizational skills, transferring/generalizing information) • Works well with "hands-on" material (i.e. labs, pictured texts, manipulative, activities) • May have poor self-image & lacks self-confidence • Works on all tasks slowly • Masters skills slowly or does not master at all
Teaching Strategies [1-4, 17,28,29]	
• Inclusion of students with slow learner into regular classes is generally an effective strategy • Another strategy is to enroll the child in the least demanding syllabus available and supplement classroom learning with one-on-one teaching by special educators and occupational therapists • The strategy to teach slow learner by E-learning environment may enhance their educational behavior	
Recommendation [1-4, 29]	
• Slow learner should receive special help outside the classroom. • Teacher should spent great deal of time with slow learner. • Do not give slow learner any designation which indicates they are in fact "slow learners." • Look for every opportunity to encourage and to reinforce the idea that the students are improving • Use tighter lesson plan because slow learners cannot usually think very creatively or spontaneously. • Prepare a lesson's content that is concrete, visual, familiar, and personally interesting to the students • Use eye-catching materials such as colored chalk or magic marker for key words in the lesson. • Keep information to no more than five pieces at one time? Because they suffer from short memory and short memory can hold 5-9 items only at a time	

TABLE III. BENEFITS & DRAWBACKS OF TRADITIONAL LEARNING VERSUS E-LEARNING

	Traditional Learning	**E-Learning**
Student Contribution	• A single student in a given period of time can express herself or himself. • just one topic which cans the student expressing his opinion at a time	• Multiple students can share their contributors in the debates and express their opinions. • Multiple topics can be convened simultaneously and the student can be involved concurrently in various topics and express his/her opinion • more ability to understand complex concepts for multiple students
Teacher Contribution	• The teacher commonly talks and speeches more than the learner.	• the learner talks more than or equal to the teacher.
Interaction between Students	• less interaction and is not recorded in reports	• higher interaction and it can be reflected in the amount of the messages which are transferred between the learners in the groups of the study and in the reports of students
Student Control of Learning Process	• can't control the process of learning	• can control the process of learning and to log in into any course at any convenient times & when they feel that they able to receive information
Student freedom	• limited freedom	• Has freedom of the social restraints of gender, perspiration and the appearance
Student Motivation	• Low motivation	• High motivation because of technology
limits of learning	• limited to place and time	• no limit on place or time
Discussion Style	• is done by the whole class	• Happens in group styles or individually.
Teacher role	• The teacher role is the authority,	• The teacher role is to direct the learners into the information and the knowledge
Subject Matter	• the teacher precedes the lesson in accordance with the curriculum and the study program	• the process of determinate the subjects, the study depends on different sources of information, such as net-experts and data banks which are located by the learner.
Learning Emphases	• the student learn "what" only because the teacher is usually busy with finishing the required topics	• the student learn "what" and "how", because , the process of learning contains research study that merges searching for and gathering information from the data banks.

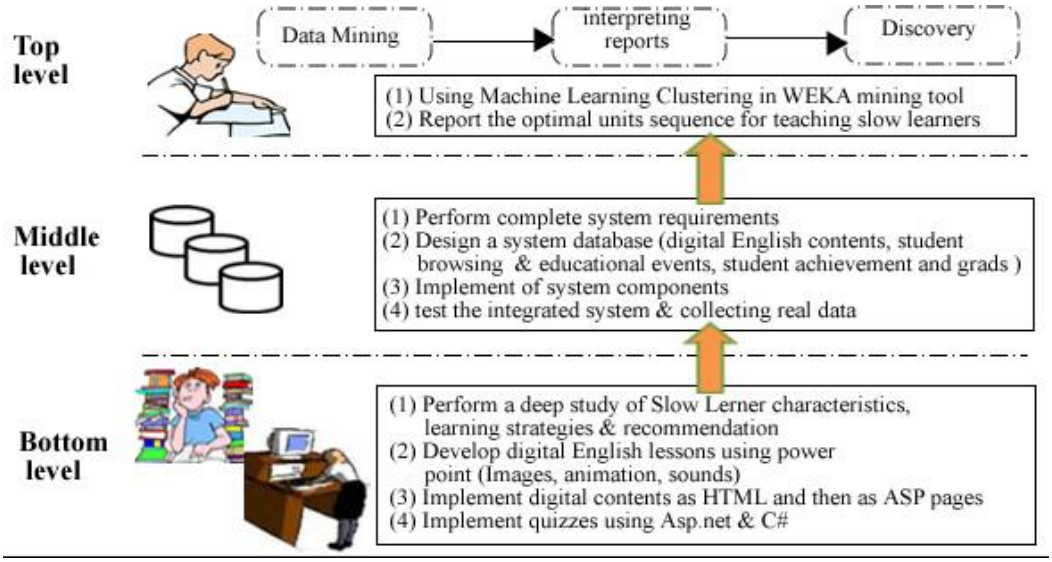

Fig. 1. The proposed integrated system architecture

IV. Traditional Learning Versus E-Learning

The process of learning can be defined as providing the knowledge for the learners by various ways such as, questioning, doing, watching and listening. Traditional learning is also known as customary education, conventional education or back-to-basics. It refers to the traditional customs which are found for a long time in the schools and the society deemed appropriate traditionally [30]. In the other hand, E-Learning is using the network and computer in teaching and transferring the knowledge and skills. These applications and processes contain "computer based learning", "Web based learning", digital collaboration and virtual classrooms. The content of the learning is transferred via internet/extranet, CD-ROM, video tape, audio tape, Internet, satellite TV. E-learning includes media in text form, streaming video form, image, animation and audio form, and it can be instructive or self-paced [30]. Table 3, shows the traditional learning versus e-learning benefits and drawbacks.

V. Clustering

Clustering is unsupervised learning that group the objects into subsets of similar features, where it can be used in many fields, including machine learning, data mining, pattern recognition, image analysis and other. Usually, the first step in clustering is to state a mathematical description of similarity [32]. There are number of criteria's available to measure the similarity between objects where the default measure is Euclidian Distance. Clustering techniques are able to deal with noisy and high dimensional data. In general, the major clustering algorithms can be classified into following categories. (1) *Partitioning algorithm*: given a database of n data records, it constructs k partitions where each partition represents a cluster and $k \leq n$. (2) *Hierarchical algorithm*: a hierarchical decomposition of data objects is created. (3) *Density based algorithm*: its idea is to keep growing a specific cluster as long as the density in the neighborhood exceeds some threshold (4) *Grid based algorithm:* it quantizes the object space into a finite number of cells that construct a grid structure and all of its operations are performed on grid structure. (5) *Model based algorithm*: it hypothesize a model for each cluster and best fit data that model [32-35].

The K-means clustering algorithm is a partition algorithm that performs one level partition of the data records where it first choose k (number of clusters desired) initial centroids. Each point is then assigned to the closest centroid or cluster, and the cluster is then updated based on the updated points assigned to it. The basic steps of k-means clustering are first determine the centroids coordinates then determine the distance of each object to the centroids, gather the objects based on minimum distance and lastly update the centroids[33,34].

VI. The Proposed Clustering Based Integrated System

The proposed clustering integrated system went through three main levels. These are bottom, middle and top, see Figure 1. In the following, a brief presentation for each of them is given.

A. Bottom Level

In this level, all lessons were developed from scratch where they contain image, sound and emotions that together form an attractive lesson environment and also consider the simulation of the slow learner student's way of thinking and connectivity between various contents. Note that no specific order of lessons is pre-stated on the slow learner's students. Ex: some students start with reading unit while others start with listening unit and so on. (Microsoft power point slides plus "iSpring" are used by this stage). For every lesson, a quiz was developed for reporting the understanding degree of each student. Additionally, a final exam is also maintained (ASP.net plus C#

TABLE IV. 24 PERMUTATION LEARNING PATTERN ACTIVITIES (R: READING, G: GRAMMAR, W: WRITING, S: SPEAKING)

1-RWGS	7-GSRW	13-WSGR	19-SGRW
2-RWSG	8-GSWR	14-WSRG	20-SGWR
3-RSWG	9-GWRS	15-WRSG	21-SWRG
4-RSGW	10-GWSR	16-WRGS	22-SWGR
5-RGWS	11-GRSW	17-WGSR	23-SRGW
6-RGSW	12-GRWS	18-WGRS	24-SRWG

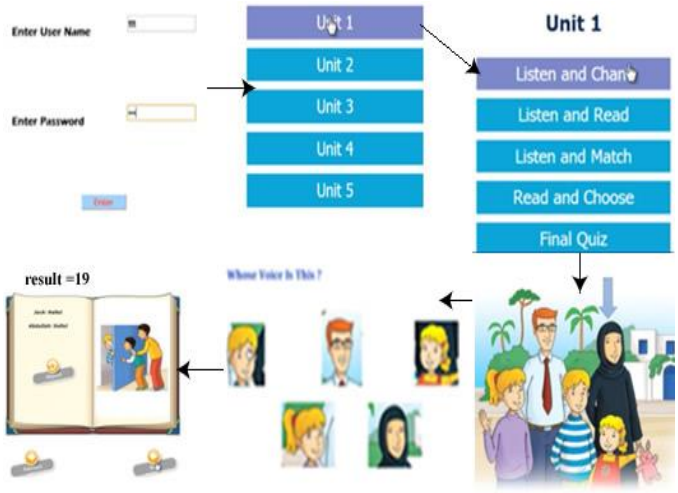

Fig. 2. Ex of a simple GUI during learning

studentId	unnitID	activity1	quiz1_score	activity2	quiz2_score	activity3	quiz3_score	activity4	quiz4_score	PatternNo	LearningPattern	Total	Grad
63	1	G	17	S	17	W	15	R	18	8	GSWR	83.75	B
63	2	S	11	R	14	W	16	G	14	24	SRWG	68.75	C
63	3	W	12	S	18	G	18	R	14	13	WSGR	77.5	B
63	4	S	14	W	15	G	13	R	11	22	SWGR	66.25	C
63	5	G	15	W	18	R	13	S	15	9	GWRS	76.25	B
64	1	G	15	S	19	R	16	W	13	7	GSRW	78.75	B
64	2	G	13	W	18	R	19	S	13	9	GWRS	78.75	B
64	3	W	18	S	17	G	13	R	13	13	WSGR	76.25	B
64	4	S	13	G	15	R	16	W	15	19	SGRW	73.75	C
64	5	W	19	R	17	S	15	G	17	15	WRSG	85	A

Fig. 3. Sample of integrating the whole system collected data

are used to accomplish this stage). Figure 2 shows a sample screen shoot of the developed lessons work flow , where the slow learner first choose the unit no, then follow a specific sequence or learning pattern, to study and perform quizzes and assigments.

B. Middle Level

In this level, the Skelton of the system database and internal structure are achieved. The design of database includes the English course dataset, the student browsing educational events and the student achievement. The SQL server 2008 was used to implement the database ADO.net and is also used to link ASP.net with the database. We have tried to aggregate the sequence log data of the slow learner into a list of features that could capture most aspects of a student's online behavior. The features we have selected are: the login frequency, the date of last login, the time spent online, the number of lessons read, the number of quizzes, the average grade obtained in the unit as a whole, the, the average best grade obtained, and the number of answers to existing questions. All of our features are normalized.

The English course dataset contains four different activities; these are Reading (R), Writing (W), Grammar (G), and Speaking (S). Each slow learner can start his learning using any sequence of these activities, and then continue studding for the rest of activities. Table: 4 shows the possible student learning activities sequences, which various among 24 patterns. Figure 3, show a sample of the slow learner data.

C. Top Level

In this level, the whole consistency and integrity of system components are also achieved. A "WEKA" mining tool is used with target of clustering task. The "WEKA" data analysis tool is a group of machine learning algorithms to solve problems used in real world. Java is the used programming language in "WEKA". It is freely available software. It is portable & platform independent because it is fully implemented in Java programming language and thus runs on almost any modern computing platform [31]. Weka also contains tools for data preprocessing. In this paper two clustering algorithms is selected from WEKA for interpreting the following results. These are Simple K-means and Expectation Maximization algorithms. Our aim with this analysis was be to determine if selecting a specific learning activities pattern or sequence will affect the overall achievements of the slow learner's students and affect their

educational performance. In addition whether the clusters show mostly qualitative or quantitative differences between the slow learner students or not?.

VII. EXPERIMENTAL RESULTS & DISSCUSSION

Our system is implemented using ASP.NET and C# with SQL database language. The results of this paper are based on random sample of data of the slow learners of elementary school in Kuwait. Each participant accessed the integrated system will participate as a total of five times instead of one time, since the course consist of five units and each unit has a different material. Thus a higher reliability of the results is obtained. Also, the system allows repeating the material to the slow learners in order to enhance their academic achievement based on scientific recommendation for teaching slow learners.

The data used in this paper was collected, and pre-processed based on real slow learner students' information in an elementary school at Kuwait. Actually, the total number of participants was 300 students with a five times login participation for each teaching unit. In each experiment, 500 records were randomly selected.

Experiment 1*: learning pattern Visualization*

This experiment visualizes the distribution of the slow learner relative to the followed pattern of learning in Figure 4. From the figure, it is obvious that some pattern was followed frequently than other patterns by the students which reflect their interest in such pattern. These are three main patterns (RWSG with frequencies =138, RWGS with frequencies =52 and RSWG with frequencies = 56)

Experiment 2*: Expectation Maximization algorithm (EM)*
Expectation maximization algorithm is an iterative algorithm for finding maximum likelihood or maximum a posteriori (MAP) estimates of parameters in statistical models. The EM[34] iteration alternates between performing an expectation (E) step, which computes the expectation of the log-likelihood evaluated using the current estimate for the parameters, and maximization (M) step. These parameter-estimates are then used to determine the distribution of the latent variables in the next E step. The result of the cluster analysis is as values that indicate the class indices, where a value '0' refers to the first cluster; a value of '1' refers to the

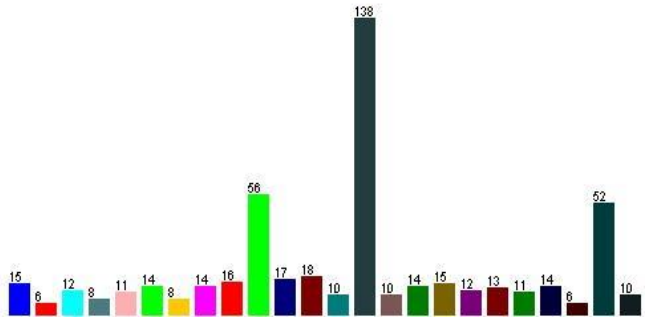

Fig. 4. 24 learning patters with total no of followed students

second cluster, etc. The class indices are sorted according to the prior probability associated with cluster, i.e. a class index of '0' refers to the cluster with the highest probability [34]. Figure 5 shows result of EM algorithm on the selected slow learner data. Figure 6: shows a visualization of results cluster. From both figure, four main clusters were detected from the data and the mapping between the learning patterns relatively to the achievements grads were resulted in the following

Cluster 0 ← B ←RSWG
Cluster 1 ← C ←WRGS
Cluster 2 ← D ← RWSG
Cluster 3 ← A ←RWGS

Experiment 3*: K-Mean cluster with k=2*

K-means clustering algorithm [34] aims to partition n records into k clusters in which each observation belongs to the cluster with the nearest mean. It is one of the simplest unsupervised learning algorithms where its main idea is to define k centroids, one for each cluster and a very good recommendation state that these centroids should be placed far away from each other. Applying the K-mean on the slow learner data with two main clusters resulted in the following mapping between the learning patterns relatively and the achievements grads of students.

Cluster 0 ← B ← RWSG
Cluster 1 ← C ← RWGS

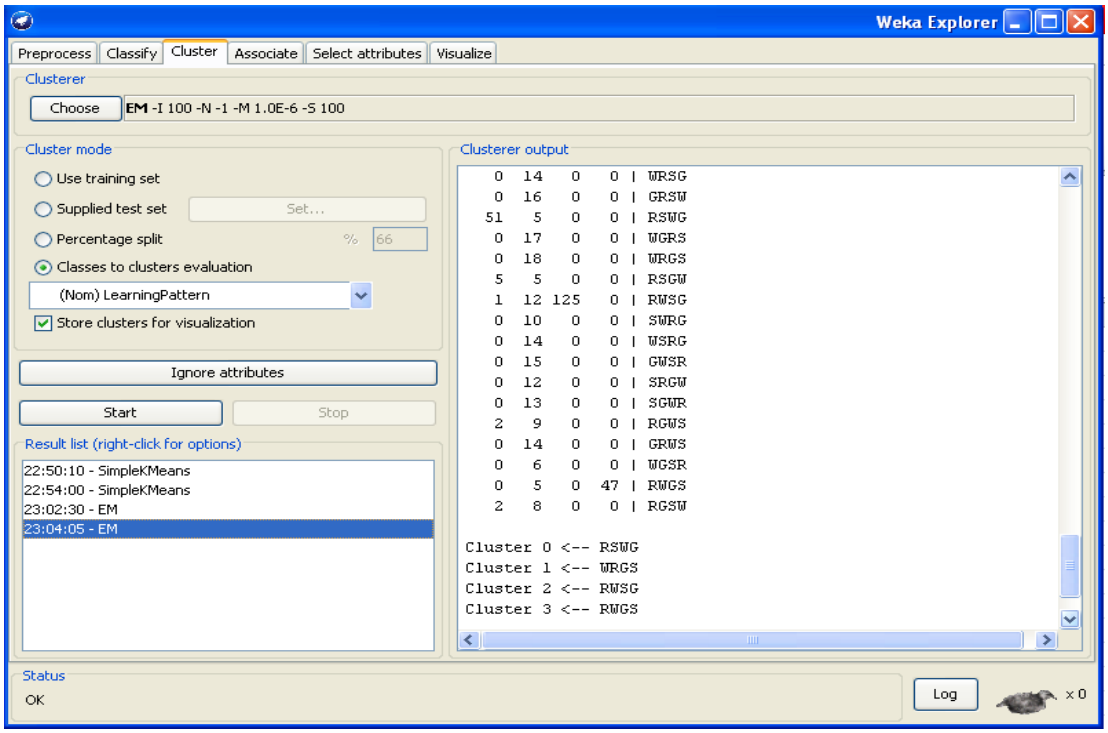

Fig. 5. Expectation Maximization algorithm results on slow learner data , no of cluster=4

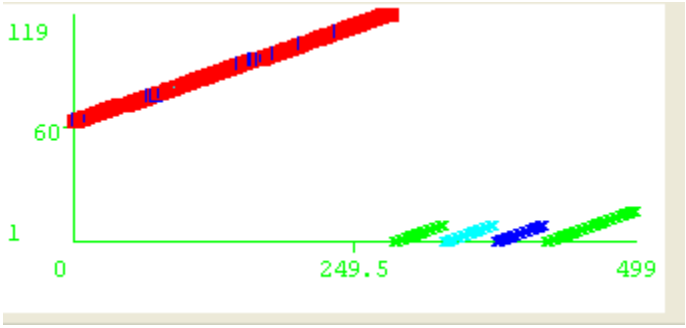

Fig. 6. visualization of Expectation Maximization algorithm on slow learner data, no of cluster=4

***Experiment 4**: K-Mean cluster with k=4*

The student's data were only quantitatively differentiated by sequence of learning activities. Applying the K-mean on the slow learner data with four main clusters resulted in the following results

Cluster 0 ← 1 ← 2 ← 3
C ← A ← D ← B
GRSW ← SGWR ← WRGS ← RWSG

Based on results of the three clustering algorithms on the collected slow learner data, an illustration of the relations between patterns and academic achievement is analyzed and hence the three algorithms reached a specific list of optimal learning pattern. This list reduced the 24 proposed learning patterns to a set of 5 optimal patterns list **(RSWG, RWSG, RWGS, GRSW, and SGWR).** Of course, the preferred list from experiment 1 is certainly included in the optimal patterns list. These five optimal patterns helped the slow learner to get grads between A, B or C which are still considered an achievement for the slow learner. In addition, the student who followed pattern RWSG in the three algorithms reached grad B with score higher than 75%. Also, student who followed patterns SGWR or SGWR got an A which is the highest academic achievements for the slow learner. Therefore, these are the optimal learning pattern in learning slow learner student

VIII. Conclusion

With the increased rates of the slow learners enrolled in schools nowadays, the schools realized that the traditional academic curriculum is inadequate. Some schools have developed a special curricula that are particularly suited a slow learner while others are focusing their efforts on the devising of better and more effective methods and techniques in teaching. In the other hand, knowledge discovery and data mining techniques certainly can help through the discovery of

hidden valuable knowledge to understand more about these students and their educational behaviors. This paper discussed the discovery of the optimal pattern of learning for elementary school slow learner students through applying two machine learning clustering algorithms Expectation maximization and K-Mean. The development stages of the proposed integrated E-Learning and mining system were briefed, where it goes through the development of digital contents of the English course with a mapping of these digital materials with environmental background of these students.

Then the Skelton of the database with a simplified graphical user interface suitable for these slow learners was also briefed. Based on the results of the three applied clustering algorithms on the slow learner data, a five optimal learning patterns list were concluded as a reduction of 24 possible combination and relative the prepared teaching material. This optimal list includes **(RSWG, RWSG, RWGS, GRSW, and SGWR)** interested patterns and certainly helped the slow learner to get grads between A, B or C which are still considered an achievement for the slow learner. Actually, the student who followed pattern RWSG in the three algorithms reached grad B with score higher than 75%. Also, student who followed patterns SGWR or SGWR got an A which is the highest academic achievements for the slow learner. Therefore, the proposed integrated clustering system is a promising assistant methodology for teaching the slow learner student.

Our suture work includes more investigation for different course material specially in mathematics. Also, different slow learner students with different grads or age level will be studied.

REFERENCES

[1] http://www.nasponline.org/publications/cq285slowlearn.html

[2] http://www.clubtheo.com/momdad/html/dlslow.html

[3] http://www.foundationosa.org/slow.htm

[4] http://www.gnb.ca/0000/publications/ss/disability.pdf

[5] Lottir Phillps, “A Study of the Preparation of English Teachers for Teaching of Slow Learners”, Olivet Nazarane College, 1970.

[6] Rashmi Rekha Borah,” Slow Learners: Role of Teachers and Guardians in Honing their Hidden Skills”, Int. J. of Educational Planning & Administration, vol. 3, no. 2, pp. 139-143, 2013.

[7] Clark, R,C.& Mayer, R.M.,” E-Learning and the science of instruction”, 3rd edition, san Francisco, CA:Pfeiffer., 2011.

[8] J.willems, “Using Learning styles data to inform e-learning design : A study comparing undergraduates, pstgraduates and e-educators”, Australasian J.of. educational technology, vol.27, no.6, pp.863-880,2011.

[9] Movafegh Ghadirli, H. and Rastgarpour, M.,, “A Model for an Intelligent and Adaptive Tutor based on Web by Jackson’s Learning Styles Profiler and Expert Systems”, Proc.of the Int. MultiConferece of Engineers and Computer Scientists(IMECS 2012) ,vol 1, 2012.

[10] Al-Khalifa, H. S. and Al-Wabel, A. S. 2005. Aided technological methods for special learning: exploratory study. Available online: http://www.gulfkids.com/pdf/Areej.pdf , 2013.

[11] Anitha, A and Krishnan,N. “A Dynamic Web Mining Framework for E-Learning Recommendations using Rough Sets and Association Rule Mining'. International Journal of Computer ApplicationS, vol.12, no.11,pp.36-41, 2011.

[12] B. M. Ramageri, “Data mining techniques and applications”, J. of CS and Engineering, vol. 1, no. 4, pp. 301-305, 2010

[13] J. Han and M. Kamber, “Data Mining: Concepts and Techniques”, 2nd ED, Morgan Kaufmann Publishers, 2006.

[14] P. Berkhin, “Survey of Clustering Data Mining Techniques”, 2002, retrieved 24th Sep, 2012 <http://csis.pace.edu/~ctappert/dps/d861-12/session3-p2.pdf>

[15] Kumar, V. and Chadha, A. “An Empirical Study of the Applications of Data Mining Techniques in Higher Education”, Int.J. of Advanced Computer Science and Applications, vol. 2, no. 3, pp. 80-84, 2011.

[16] Rashmi Rekha Borah, “ Slow Learners: Role of Teachers and Guardians in Honing their Hidden Skills”, Int. J. of Educational Planning & Administration, vol. 3, no. 2, pp. 139-143, 2013

[17] Kangaiammal, A., Silambannan, R., Senthamarai, C., and Srinath, M.,” Student Learning Ability Assessment using Rough Set and Data Mining Approaches’. I.J.Modern Education and Computer Science, vol. 5, pp.1-11, 2013.

[18] Prema, M and Prakasam, S., “ Effectiveness of Data Mining – based E-learning system (DMBELS)”, Int.J.of Computer Applications, vol.66, no.19, pp. 31-36, 2013.

[19] M. AlAjmi, S. Khan, and A. Zamani, “Using Instructive Data Mining Methods to Revise the Impact of Virtual Classroom in E-Learning”, Int. J. of Advanced Science and Technology, vol. 45, pp. 125-134, 2012.

[20] Hung, J., Rice, C., and Saba, A., “ An Educational Data Mining Model for Online Teaching and Learning”. J. of Educational Technology Development and Exchange, vol.5, no.2, pp.77-94, 2012.

[21] T. Chellatamilan and R. Suresh, “An e- Learning Recommendation System using Association Rule Mining Technique”, European J.of Scientific Research, vol.64, no.2, pp.330- 339, 2011.

[22] Mamcenko, J., Sileikiene, I., Lieponiene., “Analysis of E-Exam data using data mining techniques”. available at: http://isd.ktu.lt/it2011/material/Proceedings/6_ITTL_3.pdf

[23] Anitha, A & Krishnan,N., “A Dynamic Web Mining Framework for E-Learning Recommendations using Rough Sets and Association Rule Mining”, International Journal of Computer Applications, vol.12, no.11, pp. 36-41, 2011.

[24] Carmona, J., et.al., “Evolutionary algorithms for subgroup discovery applied to e-learning data”,. available at: http://sci2s.ugr.es/keel/workshops/docs/workshop1/SD_e-learning_ESw.pdf , 2010

[25] Dominguez, A., Yacef, K., and Curran, J. , “data mining for Individualised Hints in eLearning”, 2010.