

Reversed Roulette Wheel Selection Algorithms (RWSA) and Reinforcement Learning (RL) for Personalizing and Improving E-Learning System: The Case Study and Its Implementation

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ABSTRACT

Various mechanisms to improve learning process with the objective of maximizing learning and dynamically selecting the best teaching operation to achieve learning goals have been done in the field of personalized learning. However, instructional strategists have failed to address the necessary corrective measures to remediate immediately learning difficulties. It is necessary that an alternative, more realistic, simpler and a real time multi-based performance for personalized learning sequence be developed and implemented. Three major contributions can be asserted by the study: it personalized the learning sequence using reversed roulette wheel selection algorithm and linear ranking; the fitness value is based on real time, multi-based performance system; and it implements the reinforcement and mastery learning to motivate students and to improve their learning output. Result shows that the personalized learning sequence (PLS) were dynamic and heuristic and considers the curriculum difficulty level and the curriculum continuity of successive curriculum while producing individualized and personalized learning sequence. Data collected during 18 weeks experimental sessions, from 34%, a 54% increased has been achieved, making the overall passing rate to 88%. Digital transcripts based on students' perceptions and experiences in using the prototype positively correlates with theme analysis having a score of +.321 with positive attitude such as: *very happy, friends, motivate, improve, understanding, knowledge* and *good* were extracted from document analysis.

KEYWORDS

personalized learning sequence, e-learning, reinforcement learning, mastery learning, theme analysis.

1 INTRODUCTION

E-learning is the use of computer and internet technologies to deliver a broad array of solutions to enable learning and improve performance [1]. The 291,000,000 internet sites which include articles, books and research papers related to e-learning manifests educational technology's development and scope [2]. It is inevitable then, that the benefits of e-learning have become widespread and have increased rapidly. It offers user-friendly solutions for satisfying continuing education requirements while students are able to acquire knowledge and skills through methods that are more conducive to individual learning preferences. Furthermore, it offers visual learning benefits through multimedia which are not typically offered by any other methods. It is a good alternative to printed learning materials since rich media, including videos or animations, can easily be incorporated to enhance the learning process [3]. However, as e-learning evolved and became the fastest technology in education, many issues have emerged and have continually adapted to the ever-changing needs of learner which were driven by continuous innovation and fast-paced technology development, hypermedia and e-pedagogical strategy.

E-learning poses challenges in pedagogical perspective such as how to motivate the students to continue learning in the absence of human instruction. It needs to answer questions on how e-

learning system will cater individualization and personalization to maximize learning process and how it will remediate learning difficulty. A learner can take responsibility of his or her own learning and be allowed to personalize his or her own learning path [4]. Another issue that needs to be addressed is the dynamism of students considering their various and different prior knowledge, learning level, age, experiences, goals, learning style, cultural backgrounds and individuality [5]. Thus, educational strategists must develop an e-learning system that caters personalization, individualization or customization based on the learner's prior knowledge, prior performance and study habits. If personalization of learning path and a certain level of competence are achieved, learning benefits such as skills acquisition, knowledge transfer and increase cognition are also guaranteed.

2 RELATED LITERATURE

2.1 Personalized Learning Path

Personalizing learning path enables the dynamic insertion, customization or suggestion of content in any format that is relevant to the individual user, based on the user's implicit behaviour and preferences, and explicitly given details [6]. It is a practical and flexible way to achieve specific education and professional development goals at the learner's own pace. Various approaches to personalize learning path or topic sequencing have been explored in the area of e-learning implementations. Several researches recommended a personalized learning path using feedback, knowledge level and material difficulty [7] while other made use of personalized e-learning module through learning style, genetic algorithm and item response theory respectively [8], [9]. The work of [10] on the other hand, manipulated the sequence of problems among learners simultaneously while the works of [11] and [12] were able to sequence several kinds of teaching operations such as presentations, examples and assessments. The latest techniques in personalizing learning path is employing the

reversed roulette wheel selection algorithms and served as a bases in this paper [13]. It can be said then that personalized learning sequencing is a popular and excellent technology for web-based education.

The idea of personalized learning sequencing or PLS is to generate an individualized course structure for each student by dynamically selecting the most optimal teaching operation. Optimal teaching operation is an operation that brings the students closest to the learning goal within the context of other available operations. Most often, the goal is to learn a required knowledge up to a specific level and to minimize errors in a minimal amount of time. There is no fixed learning paths appropriate for all learners [14] and success depends on the system capability to automatically adapt the learning material to the student's educational needs to promote learning performance [15]. The findings of the experimental study showed that the effectiveness and achievements in personalized learning mode were higher, in comparison to the non-personalized learning mode [16], [17]. Although, personalized learning sequence have been successfully implemented based on the related literature, only few studies continue to mastery and reinforcement learning to remediate learning difficulty at present.

2.2 Mastery Learning

Mastery learning (ML) is one notable area of educational technology that has attracted much attention in the past. The work of Bloom [18] on mastery learning is regarded as the classic theoretical perspective with its comparison of two models of education: the traditional model and mastery model. The traditional model uses the same instruction for an entire class, regardless of aptitude. The instructor presents the required information to the students who are then tested to measure the information they have retained. Students are typically given only one chance to learn the material. The course then moves on to the next material. Once tested, students may learn

what mistakes they made, but tests are never conducted again to find out whether they have learned from those mistakes. Consequently, the amount of learning in a classroom varies among students. Students with an aptitude to learn requisite materials quickly move forward while slower students fall behind and received lower grades. In contrast, as shown in Figure 1, the mastery model varies instructions according to aptitude which results to a higher level of learning for all students. If the students have not learned the material by the first test, they can repeat it until they can achieve the required level of competence. Then they proceed to the next module. As a result, the instructor who employs mastery learning model of education hypothetically achieves high level of learning benefits.

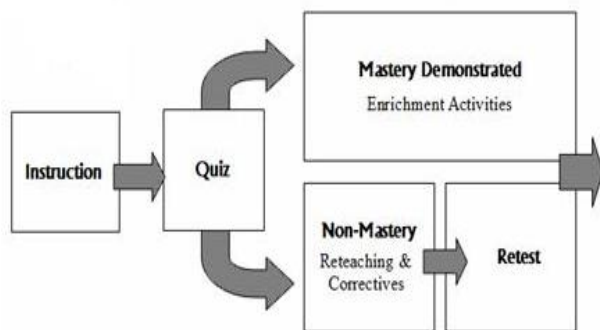


Figure 1: Learning Mastery Architecture [19]

Mastery learning has been widely applied in tertiary and primary levels in a variety of subject matter such as music [20], economics [21], mathematics [22], skills development and critical thinking [23]. Many meta-analytic studies have demonstrated consistent positive effects of reinforcement and mastery learning [13], [24]. The students were helped to master each learning unit before proceeding to a more advanced learning task in contrast to conventional instruction [25]. If such benefits will likewise be achieved in e-learning, a tremendous impact on the learning process is possible. However, during summative examinations, errors, misconceptions and

difficulties become inevitable, there is a need therefore to reinforce the learner to repeatedly read and understand the learning materials given a considerable and minimum time to repeat the examinations. The reinforcement should not be similar to the previous lesson, but similar concepts must be taught and applied to avoid boredom and discontinuation of the learning process. This issue should be taken into consideration in designing the e-learning module when a student does self-learning.

2.3 Reinforcement Learning

The idea of reinforcement learning or RL is to motivate learners to continue by giving them rewards or points for their efforts or by enforcing penalties when students cannot pass the learning assessments. E-learning is characterized by giving corrective activities to remediate misconceptions or difficulties found during computer summative. It is a principal aid in planning the corrective measures to remedy learning difficulties. For instance, activities to correct these difficulties may involve alternative materials or resources such as videos, simulations, interactive tutorials, scenario-based learning, or any type of learning activity that allow motivational preferences. Reinforcement activities may also include problem-solving exercises, or any learning activities which are stimulating and rewarding to different types of learners. If reinforcement is successful in helping the students by remediating their learning difficulties, then most students will demonstrate readiness to take remedial summative examinations. This can be used as a motivational device in a situations where students are shown directly that they can improve their learning and become successful learners. Figure 2, models the agent in the environment and how it chooses an action a_i , obtains reward r_i , and switches from state s_i to state s_{i+1} . The goal is to maximize the long term reward, where γ is called the discounting factor.

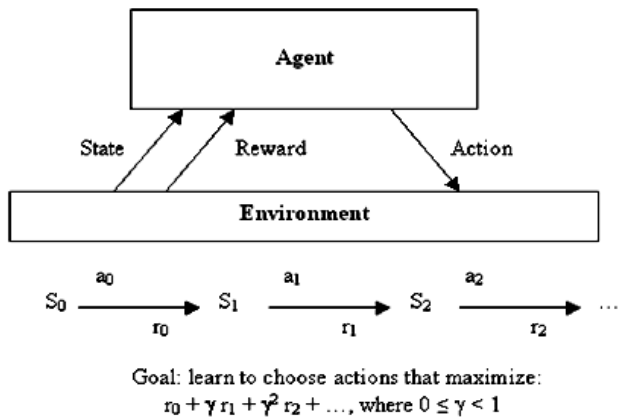


Figure 2: Standard Model of Reinforcement Learning [26].

Reinforcement learning has become a methodology of choice for learning in a variety of domain. RL can be achieved well in games and simulations. The work of [27], [28] and [29] applied reinforcement learning in multi-agent, game-playing environment, and students achieved a superior level of performance in learning complex task. The used of RL accelerates learning process by giving reward functions to students [30]. If these benefits can be transformed and then implemented in e-learning, then learning process can be guaranteed.

3 METHODOLOGY

To fully understand this section and the results presented in the succeeding results and discussion, the study is a product of almost 3 years preparations, 4 months actual implementations and decomposed to several paper published and available at SDIWC digital library. For example, to understand how a personalized learning sequence is generated, it employs reversed roulette

wheel selection algorithm and linear ranking as detailed in paper [13], [31]. It employs real time performance based data and used three mathematical conditions and 14 mathematical equations to compute the fitness value. The 300 questionnaires stored in the Item Bank, guided by Bloom Cognitive Taxonomy and were used for diagnostic, formative and summative examinations in the prototype is a product of 3 years development [32], [33] while the content or learning materials using the ADDIE model is developed and presented in paper [34]. Moreover, the prototype is available at <http://maballera.byethost7.com/elearning/>.

3.1 Conceptual Framework

After reading a prescribed lesson, educational strategist administers a brief formative assessment based on the unit's learning goal to give students information or feedback on their learning. It helps students identify what they have learned well and what they need to learn. Paired with each formative assessment are specific corrective activities for students to use in correcting their learning difficulties or misconceptions. Most educational strategist match these correctives to each item or set of prompts within the assessment so students need work on only those concepts or skills they have not yet mastered. With the feedback and corrective information gained from the diagnostic and formative assessment, prescription of what more needs to be done to master the concepts or skill is ensured. This "just in time" correction prevented minor learning difficulties from accumulating and becoming major problems.

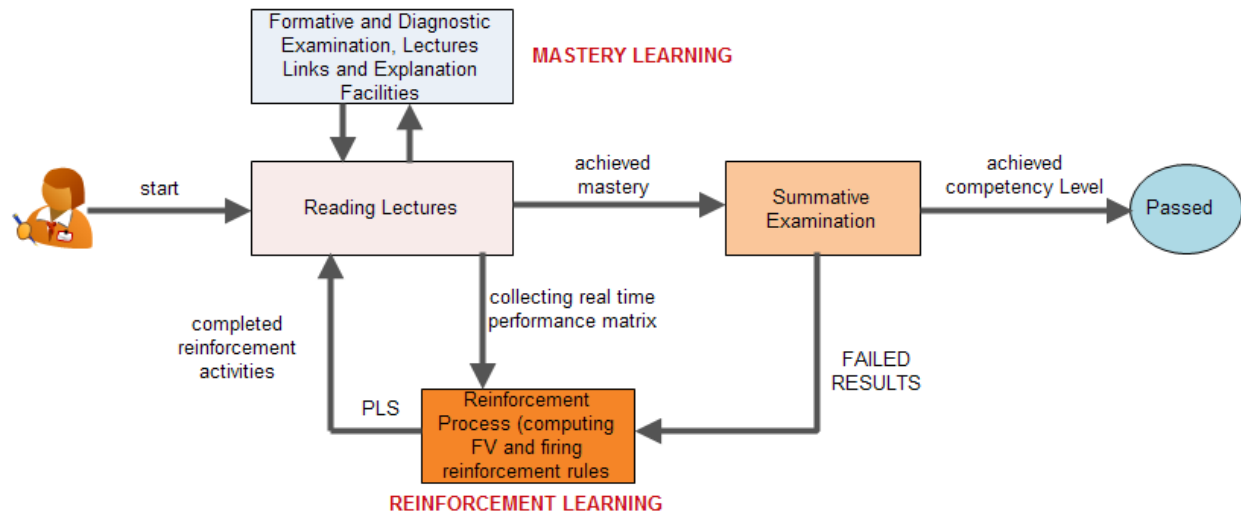


Figure 3. General Architecture of Mastery and Reinforcement Learning

Students who achieved mastery level will undergo summative examination. This is generally carried out at the end of a course and typically used to assign course grade that sums up the teaching and learning process [35]. Initially, a 60- item is randomly generated by the system for each student, extracted in the item bank with different question types. No two-students can have the same set of questions, making the examinations personalized. The number of questions selected for each lesson is proportional to the students' time in reading the learning materials. Summative examination is intended to measure the learning outcomes and report those outcomes to students. If the student achieved the passing threshold, usually 75, the student will pass the course, otherwise student will undergo reinforcement process as shown in Figure 3.

During reinforcement process, a personalized learning sequence is generated. This is a list of lessons recommended to the learners for the purpose of remediating learning difficulty after failing the summative examination. There were 60 rules ready to fire and match in the database to activate reinforcement files for particular students. The reinforcement files vary in each lesson depending on the available files stored in reinforcement table. Files or learning activities can

be in the format of PowerPoint, document, gif, video, PDF, or solved problem files which were readily available for reinforcement process. If the weights are less than the summative results in each lesson, a number of reinforcement activities were loaded to the students. The objective is to trim down the number of students who will fail the class after they are given enough time to study the lesson again, perform reinforcement and mastery and then repeat the summative examination up to third generation.

3.2 Case Study

Sirte University, is a public university in the heart of rich oiled country, Libya. It has campuses in Benjawad, Hun, Juffra and Zamzam, and satellites school that caters to 12,000 students from all walks of life. The university became then the center of economic activity until war erupted in 2012. To date, there are 14 faculties with numerous departments.

Failures of the many students in the university can be attributed to non-completion of requirements, failures in examinations, incomplete trainings, excessive absences, insufficient skills and others. The average failing mark for the last three semester ranges from 30 to 70 percent. This is a

big number of students who needs an attention. In effect, there is a low turnout of graduates because the average years a student graduates from the university is 6.5 for a 4-year course. Also, the average age the students graduate is 24 as compared to the US and Asia which is 22-23 and 19-21 years old respectively [36], [37], [38]. Recent events like the war in Libya further deteriorates academic competency as evident of high absenteeism of students due to restricted mobility and threat to security and safety. According to the composition of current university population, the male to female ratio is 1:8, making the population a majority of females. Among the female students, 90 percent is of marrying age and they are therefore basically busy with family commitments and have no time to attend formal classes.

In 2013, Sirt University reluctantly released 24M Libyan dinars (18.5 million dollars) to pay students to attend the university. A student who wanted to enroll was given 1,850 dollars per year. This is considered to be a wasted additional cost for government. Failure of students in a university setting does not totally indicate failure of understanding also. Students fail due to minimal performance indicators. For example, when a student obtains a failing mark at the end of the semester wherein 12 end chapters examinations were given, there are students who did not fail in all the examinations but rather, their grades were pulled down by the dismal results of the other examinations. In view of this, two basic questions must be answered: “Should students be encouraged to repeatedly read the module if they fail the course/s?”, “Should learners be allowed to spend their time reading all the modules instead of learning from more productive learning materials?”. Normally, educational strategist are given three weeks to prepare and compute the final grades of students and have enough time to remediate the learning difficulty of students. Educational developers and strategists should include immediate and post remediation process that will permit allowed students to skip modules that they have already learned and passed. This is

an issue that needs further attention, especially when it comes to e-learning based instruction. Learners should be given an opportunity to study and take the again provided they undergo the remediation process.

3.3 Learning Materials

The content of the e-learning materials is a product of three-years teaching and also been improved for the purpose creating an e-learning prototype. There are 12 lessons with varying subsections. The course contents were specifically designed for the students. Their backgrounds and communication problems were considered, making the content more focused in problem solving and application types of discussion. Aside from the lessons and discussion of the subsections, twenty four (24) interactive MHTML files, seven embedded videos, fourteen (14) simulations, twenty two (22) PowerPoint, forty five (45) PDF files, twenty two (22) words files, sixteen (16) executable files, sixteen (16) source codes and two (2) excel files were used

3.4 Respondents

The study was organized within the context of Design and Analysis of Algorithms class which was taught at Sirte University, Libya. The entire data collection and training lasted for 18 weeks. All learning materials and online assessments were conducted in the e-learning portal prototype at <http://maballera.byethost7.com/elearning/>. The learning materials is composed of 12 chapters, L_1 to L_{12} . All students are familiar with the use of electronic materials and had seen the implementation of the e-learning system. Students were given one week familiarization of the system flow and navigation. Diagnostic examinations were conducted every four weeks while formative examinations were administered at the end of each training module. At the end of the training, summative examination is given to determine the overall learning throughput or learning benefits in using the prototype. The passing mark is 75.

Prior to implementation, students were informed about the research and the task involved. Students were given time to navigate the e-learning system so that they would be familiar and be directly involved in the learning process. If issues arose during the learning process, the researcher provided necessary assistance in support for blended learning.

3.5 Data Collection

In this study, primary data were collected in two ways. The first was the experimental collection where various tables were populated dynamically, manipulated and extracted to generate several reports such as practice examination results, cognitive performance graphs and frequency of the practice examination or trials. The second was the survey which was divided into two parts. The first part was the measure of the internal reliability of all the questionnaires stored in the Item Bank. The second part was the acceptability of assessment design factors and the collection of student's perceptions and experiences.

RESULTS and ANALYSIS

This section presents the discussion of the results after the implementation of the reverse roulette wheel selection algorithms, mastery and reinforcement learning. Some of the results presented in this section are modified and customized for the purpose of discussion. The extracted data in different tables of the database were obtained dynamically during the learning process. In-depth analyses of the results are included to reflect the researcher's views, opinions and observations with which were strengthened and justified from the various scientific output and scholarly published materials.

4.1 Respondents

Out of the 41 students surveyed, 38 returned the post survey questionnaires; 6 were males and 32 were females. There were 28 fourth year students

and 10 were in third year. These 10 students passed already the course prerequisite. The average age of the respondents was 23.2 years old with a standard deviation of 1.6. All the respondent owned electronic devices at home and had access to the Internet. Twenty (20) had personal computer, laptops and computer tabs while 10 had personal computers only, and eight had used laptop. Of the total respondents, 20 used WIFI using Wi-Max USB technology, 15 used MyDSL and three used RiFi internet connectivity.

Thirty-eight (38) respondents out of 41 returned the survey forms, and they were asked about their internet connectivity in the preliminary questions. Results show that 100% of the respondents have access to the internet via different mediums. The students were able to access the learning modules anywhere, anytime at their own convenience and time disposal. In Libya, this learning environment is convenient and acceptable especially among woman students, since they are preoccupied with household chores, married life, and with their traditions and cultures. With a ratio of 1:8 for male versus female students, the implementation of e-learning is an excellent opportunity to lessen the learning gap. Finishing college is not a priority among the male Libyan students because the Libyan government subsidizes almost everything. Libyans focused on doing business to earn money and prepared themselves for marriage. Libyan women on the other hand, takes university education as a perfect opportunity to make themselves marketable to prospective husbands. Although this can be considered as a cultural set-up, the use of e-learning can lessen government spending, shorten the years of staying at the university, and increase the competency level of students.

4.2 Experimental Results and Analysis

This section of the chapter focuses on the experimental results and its impact to the student performance. The discussion also includes the impact of formative assessment, the personalization process and reinforcement learning

to remediate learning difficulty. The later part of this section discusses the overall effect of these various mechanisms which contributed to the tangible learning benefits.

4.2.1 Formative Assessment

The purpose of formative assessments is to promote the attainment of knowledge by the students rather than testing a body of attained knowledge. Designing a curriculum that includes many rich formative assessments will result into a student-centered approach to teaching which often leads to students' success. To achieve this objective, the system employs a forced mechanism which prevented student from proceeding to the next learning materials without passing the formative assessment at hand. It is in this process that explanation facilities, lesson links and re-loading of random questions occurred in the prototype. This flexibility allowed students to suit their knowledge and exert effort to pass every formative or practice administered. As the students went through the e-learning materials, several formative assessments were implemented. This allowed the students to recognize and address any misconceptions or learning difficulties they had during the learning process.

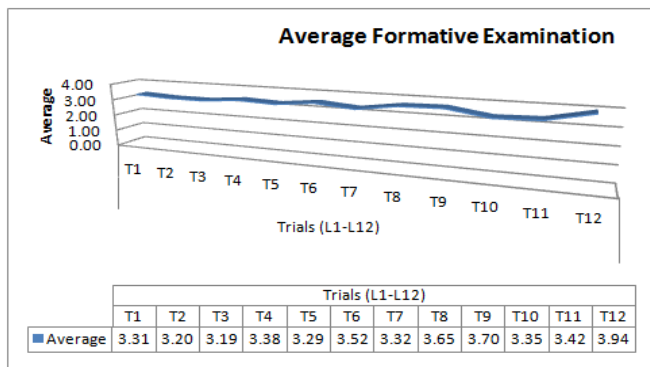


Figure 4: Average Number of Times in Taking Formative Assessment

Figure 4 shows the average number of time spent by the 41 students in taking the formative assessment for L_1 to L_{12} . The average trials for L_1 , T_1 is 3.31 while L_{12} obtained the most number of trials with an overall average of 3.94. The students

could reload as many times as they wanted the formative assessment. This allowed them to review the learning materials. The more trials were employed, the more students gained efficiency in taking a timed test in an online format. Preview questions were used to test their current knowledge and for them to be familiar with the questionnaire formats which were similar to the ones given during summative examinations. By conducting these trials, a student would understand which domains he/she was proficient in and in which areas he/she would require additional study and preparation. Each offered questions which were randomly selected from the Item Bank. At the end of each set of eight questions, student would be able to see the scores, and give feedback on the answers.

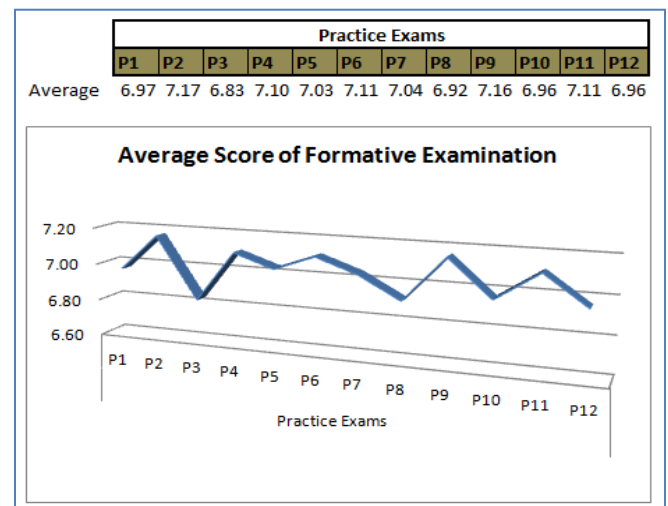


Figure 5: Average Score in Practice Examination

The graph in Figure 5 shows the average score of the class in taking practice or formative assessments. The highest overall average score P_2 is 7.17 for L_2 while P_3 with 6.83 for L_3 is the lowest. The e-learning prototype dictated that only 6 out of 8 score would be recorded in the database, forcing the student to study harder until a competency level was achieved. If the student failed the formative, he/needs to reload a new formative assessment. The trial table in Figure 4 was updated every time a new formative was reloaded to a particular student. The Item Bank contains over 300 questions and distributed across

three examinations extracted from 12 different question types table. These questionnaires can test students' knowledge while the answers, explanations and further reading links improve student's learning. Doing practice several times enabled students to systematically go through the Item Bank and allows them to access in questions from all topics relevant to the current examination in a random pattern. These encouraged students to answer as many questions as possible, testing their knowledge on multiple topics. It followed the "practice makes perfect" attitude. The study shows that a 4.3 and 5.7 percentage points overall is gained from practice [39], [40]. The results indicated that online practice significantly improved student learning and examination performance. Practice testing is more powerful, useful for learners of different ages and abilities. It is more far effective than summarization, highlighting, keywords mnemonics, imagery and rereading [41]. The results of the study show how students benefited from the prototype.

4.4.2 Diagnostic or Bloom Taxonomy Assessment

The diagnostic or Bloom Cognitive Taxonomy is a special assessment that measures the cognitive development of the student while taking the e-learning course. This 60-item assessment was specifically designed based on the Cognitive Schema and readily extracted from the Item Bank. The assessment was taken every four weeks during the experimental sessions. The assessment was equally divided to six categories specified in the Bloom Cognitive Taxonomy. The examination must be entirely based on the use of all six levels of the pyramid. For a student to evaluate his/her cognitive development he/she needs to *Remember* the basic facts. But beyond that, the student has to *Understand* the significance of those facts, and their interrelatedness, *Apply* them to solve real life problems, *Analyze* everything from all possible alternatives and study the results. After which the student has to *Evaluate* several alternatives or solutions and which of these is most

reliable. He/she has to decide which of the several alternative answers is most appropriate in a particular case. Lastly, the student has to *Create* knowledge and experience from multiple sources into a high-order schema which will equip him/her to deal with the domain more effectively.

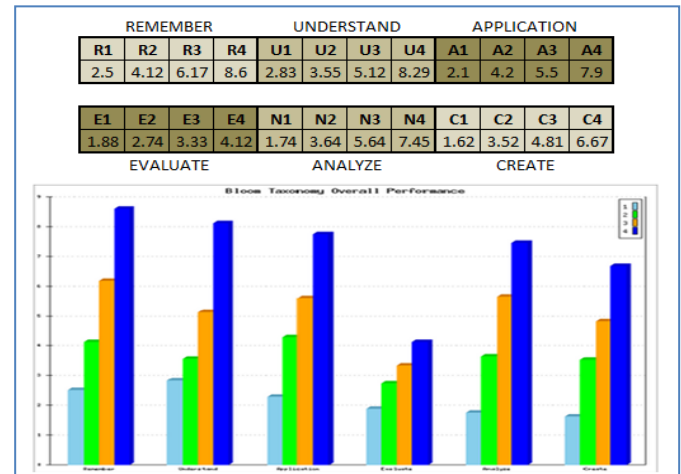


Figure 6: Average Cognitive Graph Output

The graph in Figure 6 shows the overall class average of the cognitive development of students taken every four weeks during the training. It must be noted that the cognitive level of the six categories increased. The *Remember* category, for example, had an initial average of 2.5 for R1, 4.12 for R2, 6.17 for R3 and 8.6 for R4. These initial scores clearly represent 25% of the R1 followed by an increase of 16% for R2, an increase of 20% for R3 and an increased of 24.3% for R4. Similarly, as the other learning process or training neared its end, the individual average score increased. As further shown in the graph, the category with highest gain is *Remember* since it is the easiest among the six categories while *Evaluate* has the lowest learning gain. The purpose of this was just to determine whether students would improve their learning by recalling lessons that they had read and understood as they went through the sessions. As a general observation and as shown in the graph, students increases their cognitive domain at different levels. However, these results cannot be interpreted as truly cognitive gain due to the absence of a single

domain during testing. The questions were defined and extracted from various topics. To compensate for this gap, the study examined the cognitive development and its relationship to the experiences and perceptions of the students in using the prototype. The study employed Semantria, a special software that can compute and determine whether the coded transcripts of the student is positive, negative or neutral. During the post survey, the students were asked to write briefly their reactions, perceptions and experiences in using the system to correlate the results of the cognitive development. Out of the 38 students, 35 wrote their reactions, perceptions or experiences in the survey form. Their responses were coded and transformed into digital transcripts for further analysis. Figure 7 shows the output of the Semantria and reveals that the digital transcripts are positive with a score of +.321. Several words reveal and can attribute to this attitude. As shown in the figure, the words are *very happy, friends, motivate, improve, understanding, knowledge, good*. Students who have high cognitive benefits and self esteem will likewise reflect these in life or in their reactions to objects or surroundings [42]. Being happy and positive increases the overall self-esteem and partly results to good school performance [43]. Thus, it can be concluded that

the results coincide with the findings that being happy results to "making reasonable progress towards the realization of a goal" [44]. To further strengthen the findings, Semantria extracted five entities from digital transcripts and identified two positive sentiments and 3 neutral leading to positive. These results can be seen in Table 1. No negative feedback is received from the 35 coded entities. Sentiment analysis is the process of detecting positive, negative, or neutral feelings in a piece of writing [45]. Semantria software is an information-gathering behavior that discovers what other people think.

Table 2 shows the five themes extracted from the digital transcript. They are *practice examinations, solving problems, class discussion, critical thinking* and *study online* with their respective themes count of 4, 3, 2, 2, 2. The theme sentiment score is between -1 and +1 is considered neutral. The overall theme sentiment polarity is neutral. However, neutral improves the overall accuracy and should not be considered as a state between positive and negative but as a separate class that denotes the lack of sentiment [46]. The sentence "the weather is hot" for example, cannot be considered negative or positive.

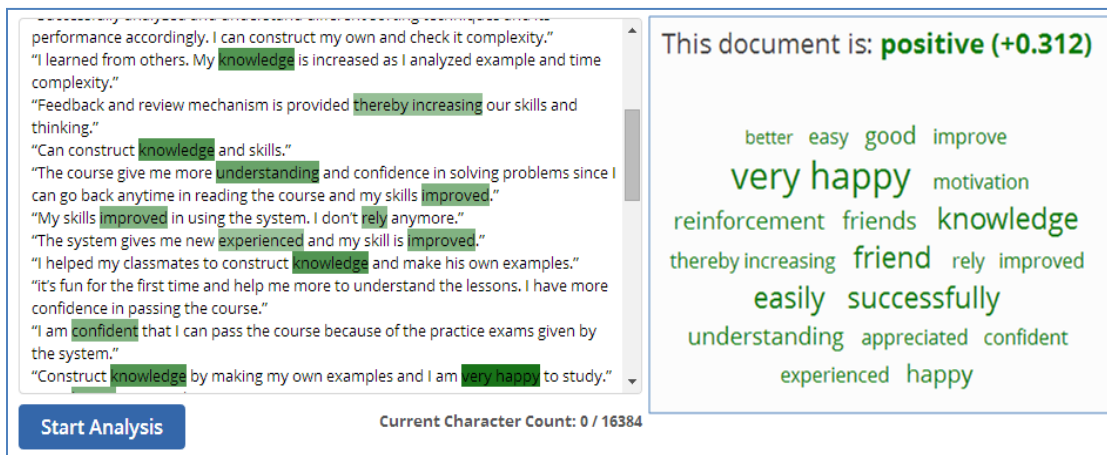


Figure 7: Semantria Analysis of the Digital Transcript

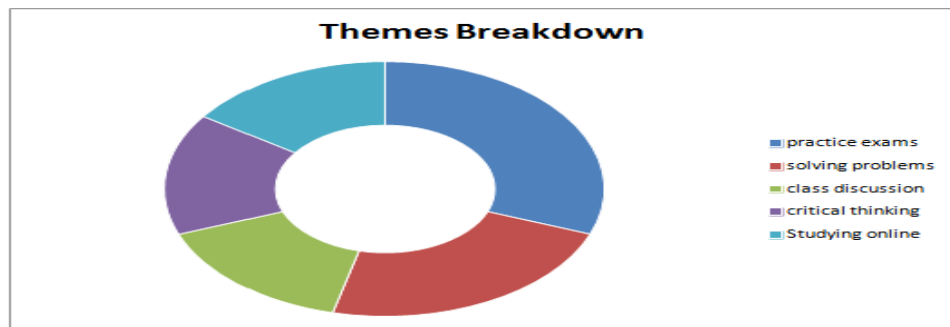
Table 1: Entity Sentiment Breakdown of the Digital Transcripts

Entity	Entities Count	Entity Type	Positive Entities	Neutral Entities	Negative Entities
"My friend and I help	1	Quote	1	0	0
"My skills improved in	1	Quote	0	1	0
"My skills is improved,	1	Quote	0	1	0
"Self confidence is	1	Quote	0	1	0
"The computations of	1	Quote	1	0	0

Entity	Positive	Neutral	Negative
"My friend and I help each other both online and blended learning."	1	0	0
"My skills improved in using the system. I don't rely anymore."	0	1	0
"My skills is improved, I was able to read the materials and clarify things during class discussion. The e-learning is new in the university."	0	1	0
"Self confidence is developed for me though it is the first time using the e-learning system."	0	1	0
"The computations of my exam result is not shown, but I am happy because it's a new teaching methods. I am more confident now."	1	0	0

Table 2: Themes Extracted from the Digital Transcript

Theme	Themes Count	Theme Sentiment Score	Theme Sentiment Polarity
practice exams	4	-0.00590241	neutral
solving problems	3	0.064992435	neutral
class discussion	2	0.313600004	neutral
critical thinking	2	0	neutral
Studying online	2	-0.057878751	neutral



4.4.3 Personalization Analysis

Personalized learning sequence or PLS is a lists of lessons recommended by the system to undergo reinforcement in order to remediate the learning difficulty. For the purpose of discussion, a partial list of student who went for reinforcement was extracted. Nevertheless, some of the properties observed were sufficient to make a generalized results.

Table 3 shows the 18 out of 27 students who underwent reinforcement process with their corresponding ID numbers and their various PLS.

Initially at Level 0, all student read the materials at the sequence of $L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$. After reading all the materials and successfully completing all the requirements enforced by the system, the student then took the first set of summative . Students who failed the underwent the first level of reinforcement. Student ID 602164 was given a chance with a new sequence $L_6 \rightarrow L_3 \rightarrow L_{12} \rightarrow L_1 \rightarrow L_7 \rightarrow L_{11} \rightarrow L_4 \rightarrow L_{10} \rightarrow L_2$. A total of 9 or 75% of lesson was recommended by the system and the student luckily passed after reinforcement. The case of student 602164 shows that regardless of the number of lessons recommended by the

system, the student will still pass the course if given the chance. Many students passed the course undergoing the same process wherein after the reinforcement stage, rewards were given by allowing them to read again the reading materials. Another student ID 1102180 underwent reinforcement level 1 with the following personalized learning sequence: $L_{12} \rightarrow L_3 \rightarrow L_6 \rightarrow L_9 \rightarrow L_5 \rightarrow L_4 \rightarrow L_1$. There was a decrease of 41% on the number of lessons to re-study. However, the student failed the second summative forcing the system to recommend a new personalized learning sequence $L_5 \rightarrow L_1 \rightarrow L_{12}$. This is a 43%

decrease on the number of lessons to re-study based on the previous learning sequence. The student passed after the second level of reinforcement, similarly with other learners but with different learning sequence. Notice that the proposed learning path or sequence can simultaneously consider both the curriculum difficulty level and the curriculum continuity of the successive curriculum while implementing the personalized learning sequence of the learning process. In this way, the system guaranteed that students would pass the e-learning course as it gradually eliminated the lesson in the curriculum vector while increasing the gap of passing the competency level.

Table 3: Summary of Personalization Process

Stud_ID	Generation		
	No Reinforcement (Level 0)	Personalized Learning Sequence Level 1	Personalized Learning Sequence Level 2
802092	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_4 \rightarrow L_1 \rightarrow L_3 \rightarrow L_5 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_2 \rightarrow L_8$	
802137	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_6 \rightarrow L_1 \rightarrow L_4 \rightarrow L_{10} \rightarrow L_{12}$	$L_6 \rightarrow L_{12} \rightarrow L_1$
802151	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_4 \rightarrow L_9 \rightarrow L_{11} \rightarrow L_{10} \rightarrow L_3$	$L_{12} \rightarrow L_4$
802197	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_7 \rightarrow L_9 \rightarrow L_4 \rightarrow L_{12} \rightarrow L_2 \rightarrow L_8 \rightarrow L_5$	$L_{12} \rightarrow L_9 \rightarrow L_2 \rightarrow L_4$
802236	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_1 \rightarrow L_6 \rightarrow L_2 \rightarrow L_{11} \rightarrow L_7 \rightarrow L_{10} \rightarrow L_4 \rightarrow L_8 \rightarrow L_5$	$L_{12} \rightarrow L_{11} \rightarrow L_{10} \rightarrow L_1 \rightarrow L_4 \rightarrow L_5$
802491	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_3 \rightarrow L_4 \rightarrow L_2 \rightarrow L_1 \rightarrow L_7$	$L_2 \rightarrow L_1$
802513	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_6 \rightarrow L_9 \rightarrow L_4 \rightarrow L_{11} \rightarrow L_2$	$L_{11} \rightarrow L_2$
1002043	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_4 \rightarrow L_6 \rightarrow L_{12} \rightarrow L_8$	
1002045	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_1 \rightarrow L_6 \rightarrow L_8 \rightarrow L_{11} \rightarrow L_5$	$L_{12} \rightarrow L_8 \rightarrow L_{11}$
602164	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_6 \rightarrow L_3 \rightarrow L_{12} \rightarrow L_1 \rightarrow L_7 \rightarrow L_{11} \rightarrow L_4 \rightarrow L_{10} \rightarrow L_2$	
802092	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_1 \rightarrow L_5 \rightarrow L_4 \rightarrow L_8 \rightarrow L_{10} \rightarrow L_2$	$L_{12} \rightarrow L_1 \rightarrow L_4 \rightarrow L_2$
802141	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_1 \rightarrow L_9 \rightarrow L_3 \rightarrow L_{10}$	
802245	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_3 \rightarrow L_{11} \rightarrow L_7$	$L_3 \rightarrow L_{11}$
802487	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_8 \rightarrow L_{11} \rightarrow L_{12} \rightarrow L_4 \rightarrow L_1 \rightarrow L_3$	$L_1 \rightarrow L_{12} \rightarrow L_3 \rightarrow L_{11}$
802592	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{10} \rightarrow L_{11} \rightarrow L_1 \rightarrow L_9 \rightarrow L_4 \rightarrow L_7 \rightarrow L_3$	$L_1 \rightarrow L_4 \rightarrow L_9 \rightarrow L_{10}$
902158	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{10} \rightarrow L_1 \rightarrow L_6 \rightarrow L_{11} \rightarrow L_{12} \rightarrow L_2 \rightarrow L_3$	$L_2 \rightarrow L_{12} \rightarrow L_3 \rightarrow L_1$
1102180	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_{12} \rightarrow L_3 \rightarrow L_6 \rightarrow L_9 \rightarrow L_5 \rightarrow L_4 \rightarrow L_1$	$L_5 \rightarrow L_1 \rightarrow L_{12}$
1102182	$L_1 \rightarrow L_2 \rightarrow L_3 \rightarrow L_4 \rightarrow L_5 \rightarrow L_6 \rightarrow L_7 \rightarrow L_8 \rightarrow L_9 \rightarrow L_{10} \rightarrow L_{11} \rightarrow L_{12}$	$L_8 \rightarrow L_3 \rightarrow L_6 \rightarrow L_1 \rightarrow L_2$	

The results are heuristic yet they guarantee that the new learning sequence becomes smaller as the process approaches the stop criterion. Being heuristic in nature, there is a minimal chance that a lesson with a very high fitness value will be selected. This mechanism is leveraged by the rule-base punishment system in the form of giving minimal reinforcement. Instead of recommending all the lessons which have failed numerical value, the system relies on the random numbers as filtering mechanism. Once a personalized learning

sequence is recommended by the system, the students will be directed to undergo mastery and reinforcement process.

4.4.4 Reinforcement Analysis

Reinforcement process refers to the overall learning activities that remediate learning difficulty after failing the summative. This mechanism is immediately activated for a student who will be given a chance to re-study the learning

materials. The lesser the fitness value, the lower the reinforcement process as recommended by the rule-based reinforcement mechanism incorporated in the system. Table 4 shows the various reinforcement statistics accumulated by the students before passing the course. Thirty (30) additional files with different formats were given

to student 602164. The student was also administered reinforcement level 1, 72 corrective activities, with 9 formative assessment or trials with an average of 6.67 and with a total rewards of 3.56. On the other hand, student 1102180, received 17 number of files, reinforcement level 2, 80 corrective activities, 10 number of trials for formative assessment and has an average of 7.17 and with a total reward points of 5.43.

Table 4: Summary of Reinforcement Process

Stud_ID	Number of Reinforcements	Reinforcement Level	Correctives Item	No. of Trials	Average Score	Rewards
802092	32	1	64	10	6.75	4.78
802137	16	2	64	8	7.33	4.98
802151	8	2	64	8	6.92	6.42
802197	11	2	88	11	6.42	4.88
802236	25	2	128	16	7.17	3.63
802491	9	2	56	7	6.92	5.02
802513	7	2	56	7	6.58	5.38
1002043	21	1	32	4	6.92	5.63
1002045	13	2	72	9	7.17	5.03
602164	30	1	72	9	6.67	3.56
8020920	14	2	88	11	7.58	5.18
802141	13	1	32	4	7.08	4.21
802245	7	2	48	6	6.83	5.31
802487	12	2	80	10	7.17	5.43
802592	12	2	88	11	7.00	5.89
902158	13	2	88	11	7.08	5.22
1102180	17	2	80	10	7.17	5.43
1102182	1	1	40	5	7.17	4.59

Reinforcement is among the many psychological tools that are used for teaching students. The two main kinds of reinforcement include, negative and positive reinforcement. Negative reinforcement attempts to enhance the learning process by eliminating or remediating learning difficulty (employing corrective measures). Positive reinforcement on the other hand, works by rewarding students based on their effort. Positive reinforcement is used for motivating students. Giving rewards to students who attain certain competency level will motivate them to study

better, and increase their participation and effectiveness. Student who are acknowledged for their good work in their studies are more likely to succeed [47].

4.4.5 Learning Gains

The results based on the implementation of the prototype that incorporated the PLS and RL are considered successful. Table 5 shows that among the 41 students surveyed, 14 or 34% passed the course without reinforcement process. This means

that 66% of the students failed the course. Out of the 27 students, 10 or 25% passed the course after reinforcement level 1 while 17 or 41% underwent reinforcement level 2. Out of these 17 students, 12% failed the course. After all the reinforcements

were administered, 22 student passed the course which is 54% of the total number of students studied. This achievement can be attributed to practice, personalized learning sequence and reinforcement process. From 14 students or 34% of the total number who passed the course without reinforcement, an additional 22 students or 54% passed the course after reinforcement. This is a

total of 36 students or 88% who achieved competency level. The remaining five students or 12% of the total number discontinued the learning process for various and personal reasons.

The results of the study can greatly help improve the teaching environment of Sirte University. With the implementation, the rate of students passing the course will increase and this increase will be guaranteed in the years to come. This will lead to an increase in the number of graduates of the University, decrease in the number of years of residency of the students and reduction of financial support by the government to the University.

Table 5: Overall Benefits of PLS and Reinforcement

	No Reinforcement	Reinforcement	
		Level 1	Level 2
Students	14	10	17
Percentage	34%	25%	41%
		66% (27)	
Failed (After Reinforcement)		12% (5)	
Passed After Reinforcements		54% (22)	
Total Student Passed	88% (36)		

5 CONCLUSIONS

Three major contributions in the field of e-learning can be asserted by this study: it personalizes the learning sequence using reversed roulette wheel selection algorithm blended with linear ranking; the fitness value is based on real time, multi-based performance such as examination, study and review matrix; and it implements the reinforcement and mastery learning to motivate students and improve their learning output. The personalized learning sequence results were dynamic and heuristic since it inherited the property of genetic algorithms. The proposed learning path or sequence could simultaneously considers the curriculum difficulty level and the curriculum continuity of successive curriculum

while implementing personalized learning sequence in the learning process. The system guaranteed that students would pass the e-learning course as it gradually eliminated number of lesson while narrowing the gap of not passing or getting a certain competency level. Although the results were heuristic and dynamic, the PLS guaranteed that the new learning sequence became smaller as the process approached the stop criterion. Being heuristic in nature, there was a minimal chance that a lesson with very high fitness value was selected.

Based on the case study and live data collected during the experimental sessions, from 34%, the passing rate of the students is increased by 54% making the overall passing rate to 88%. The i

increased of 54% is the combined results of 25% from reinforcement level 1 and 29% from reinforcement level 2 and passed summative. The increased can be attributed to the reinforcement process and mastery learning where various control mechanism is implemented to guarantee learning process. The reinforcement process is governed by the 60 punishment-rule based system and the examination performance matrix. The higher the examination performance the lower the random reinforcement process. Another factor attributed to the increase of learning output is taking three assessments module such as Bloom Cognitive, formative and summative. Students get familiar and practice multiple times. The graph of the Bloom cognitive development significantly increases in all phases of the taxonomy. The academic result positively correlate with the document sentiment and theme analysis. The document sentiments of the digital transcripts is positive with a score of +.321. Theme analysis on the other hand reveal a positive attitude as shown by the extracted words such as: *very happy, friends, motivate, improve, understanding, knowledge and good*. It can be concluded then that if the e-learning will be implemented, the academic performance of the student will improve. Through e-learning, students can study anywhere, and at their own convenience whenever online learning is possible and accessible.

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