AN ENHANCED INTELLIGENT LEARNING ENVIRONMENT FOR E-LEARNER USING COGNITIVE ARCHITECTURE - ACT-R

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ABSTRACT

The main goal of this research is to build an enhanced learning environment for e-learner using the cognitive architecture ACT-R(Adaptive Control of Thought—Rational) [7,8]. This proposed new intelligent learning environment is applied to manage and monitor the dynamic behavior of the learner and capture the learner's emotional status like active, high arousal, displeasure and sleepy mood. This intelligent architecture will modulate the learning content based on the emotional status of the learner. So that learner's emotional status is also included in E-learning which is similar to the pedagogical method where the teacher can understand the general mood of learners and modulate the method of delivery. The model that we have developed for the subject System Software has proved that the learner's outcome is better in our model than some of the other existing models. We have also included learner's behavioral history as feedback to our system for the further improvement of the learning process.

Keyword*: E-learning, Cognitive Architecture, ACT-R*

1. INTRODUCTION

E – Learning refers to the process of interpreting information and communications technology (ICT) in learning as well as teaching [1]. This supports a collection of applications and processes in the field of education such as digital collaboration, computer-based learning, and virtual classrooms where the content is delivered through the internet, interactive TV, audio and video recordings etc. E – Learning is the method of psychological experience one receives to improve his knowledge. There are two types of e – learning methods. They are 1) Synchronous and 2) Asynchronous [1,12]. Synchronous learning is the process of exchanging information and ideas with more than one participant working collaboratively at the same time. E.g. Face-to-face discussions such as Skype conversations, or chat rooms. Asynchronous learning is the use of technologies such as email, blogs, wikis and social networking using web2. 0. It is highly beneficial for anytime and anywhere learning. Both these methods are totally dependent on self - motivation, self – discipline and effective communication.

1.1 Categories Of E-Learning

1.1.1 Courses

Some learning management systems such as WebCT and Blackboard are used by educational institutions. Educational course materials are updated with different media and uploaded to a networked environment in order to perform online access [2]. In order to achieve a better innovative coursework, courseware designers added innovative presentations such as simulation, storytelling etc.

1.1.2 Blended Learning

This type of learning is also called as Integrated Learning which is a combination of face – to face and online learning which includes various delivery methods such as collaboration software, computer communication practices and web-base courses with face to face instruction. This method adds efficiency to the classroom instruction [3,13] and also permits increased information review outside of classrooms.

1.1.3 Communities

Business environment changes frequently. So, yesterday's solutions didn't solve today's problems. Hence, Problem solving needs different perspectives, so that it is possible to create understandable solutions [3] and implementation environment. This can be achieved by online communities where people interact [2] with other members of the organization globally.

1.1.4 Learning Network

This Network develops and maintains relationship with people [2] and information in order to support each other's learning where the people are engaged online with each other. Knowledge workers can utilize this personal learning network [4] so that they can remain current in their own field.

1.1.5 Knowledge Management

This is a challenging task which creates an atmosphere Between people to share knowledge and exchange information. The duplication of KM [3] and concepts involved in e – learning, explores the strong connections between various fields [5].

2. PROBLEM STATEMENT

The cognitive architecture takes account of the student's mental state and caters to their mood when it is merged with the E-learning method. Hence it paves the way for a better form of understanding, which also considers listening capabilities of the student's which is the unique characteristic of the pedagogical way.

3. RELATED WORKS

In an Intelligent Learning environment the learner's psychological behavior is unpredictable. So we need a teacher or tutor dynamically to monitor the Learner's emotion [10,11]. Cognitive Architecture plays a major role in creating an intelligent system [6] which is very similar to human intelligence. The main purpose of creating cognitive architectures is to model the human performance during multitasking. There are two design properties to be considered in the development of any cognitive architecture. They are memory and learning. Memory serves as a repository for background knowledge, whereas learning shapes the knowledge. Using these two properties, higher – order functions and intelligent capabilities are built.

Cognitive architecture can be broadly classified as follows:

1. Symbolic 2. Emergent and 3. Hybrid.

The various types of Cognitive systems are as follows:

3.1 Symbolic Architectures:

Symbolic architectures mainly focus on processing the information and realizing the cognitive functions. As the name suggests, this approach makes use of symbols in order to support information processing and utilize a centralized control over that information. This method stresses the memory, executive functions by accessing the semantic memory to retrieve the knowledge. Examples of symbolic cognitive architectures are as follows.

3.1.1 SOAR

"State, Operator And Result" is a rule – based cognitive architecture which models human intelligence which records the knowledge in the form of rules which is formulated by a technique called chunking. SOAR [6] demonstrated various cognitive functions such as complex rule sets in planning, problem solving, but that architecture have not yet integrated all these extensions.

3.1.2 EPIC

Executive Process Interactive Control[14] aims at modeling cognitive activities through processors which are interconnected and works in parallel. Even though this system focuses on multiple tasks, the combination of EPIC and SOAR are widely used.

3.1.3 ICARUS

The main aim of this system is to provide an integrated cognitive architecture [6] which specifies reactive skills and consists of various modules. In this, there are two types of memory as follows.

a) Conceptual memory contains useful information about various objects and their relationships.

b) Skill memory contains useful information about how to do such things.

Here the main disadvantage of ICARUS is concurrent processing is difficult.

3.1.4 NARS (Non-Axiomatic Reasoning System)

NARS is a reasoning system which is based on a language to represent knowledge, semantics, and set of rules that performs various cognitive functions. The non – axiomatic logic is widely used during the adaptation with insufficient knowledge and working with patterns of information [6,15]. The disadvantage is that they solve only simple problems.

Disadvantage of Symbolic architecture:

It is not possible to handle large amount of information.

This architecture is unable to manage higher – order cognitive functions. The symbolic approach is inefficient in Neuro linguistic processes.

3.2 Emergent Architectures:

Emergent architectures collect the context – specificity of the performance of Humans and manage low – level information simultaneously.

Here the learning methodologies can be as follows:

i) Associative

ii) Competitive

iii) Correlation – based learning

Associative learning is a form of supervised learning which maps specific input to specific output, which remembers the reactions and auto associations.

Competitive Learning comes under unsupervised learning where all the processing elements (PE) compete with each other in order to become active.

Correlation – based learning creates a model by collecting the properties of the incoming signals.

3.2.1 NuPIC (Numenta Platform for Intelligent Computing)

NuPIC [5] architecture is based on HTM (Hierarchical Temporal Memory) technology where each node in the network implements learning and memory functions. In order to recognize new or similar objects, each level in the network is trained to memorize spatio – temporal objects. The drawback is that this architecture is not tested in large applications.

Disadvantage of Emergent architecture:

- It is difficult to realize high – level cognitive functions.

3.3 Hybrid Architectures:

In order to develop a complete framework for cognition [6], a hybrid architecture can be used which is a combination of both symbolic and emergent architectures. The main benefit of this architecture is it is possible to perform all levels of processing such as from stimuli to higher level cognition - **ACT – R.**

ACT – R is a theory of cognition developed by John Anderson at Carnegie-Mellon University, which models how human beings recollect a lot of information from their memory and how they divide their task into subtasks to solve the problems. It performs the entire range of cognitive tasks of humans and describes the mechanisms used in detail.

How ACT – R used in E – learning?

The main aim of this work is to develop an intelligent system using ACT – R for Interactive Learning. Many interactive elements can be used to support interactions, demonstrations among objects and the basics of learning. Here in e –learning, there are various types of interactions such as making corrections, clearing their doubts and demonstrations through effective videos. All these interactive elements should be automated using the methods of ACT – R.

ACT-R is a hybrid cognitive architecture that predicts the detailed human behavior. Also In the real world applications, this architecture has the capability to integrate knowledge of human cognition into the computational models. Such models include various tasks in order to provide details about the human behavior that is interacting with a complex environment. ACT – R acts as an interface between the agent and the environment. ACT – R operation is efficiently in a dynamic environment due to its capability of pattern matching. Since there is integration between various modules, ACT – R has the capability to provide a better solution in identifying the human behavior. This architecture consists of two types of knowledge structures such as chunks and productions. Chunks are used to represent declarative knowledge and productions are used to represent procedural knowledge. The availability and applicability of symbolic knowledge can be determined by the parameters defined in order to predict the performance of ACT – R.

4. PROPOSED WORK

ACT – R is the cognitive architecture that provides an E - learning system that enables the learners to enhance their learning and writing capability such as assisting them in both theory and practice. Fig.1 defines a relationship between interaction, learning and learners' feedback.

In the proposed work, to improve the efficiency, the hybrid model called ACT – R model is being used.

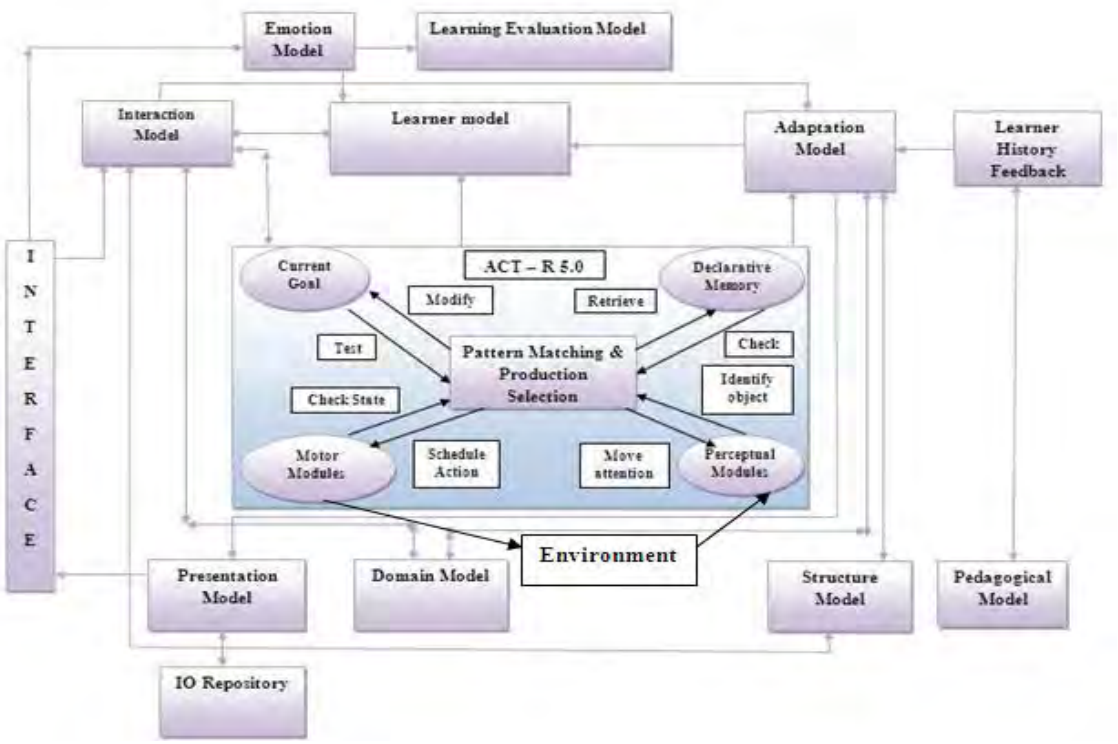

Figure 1. E-Learning Environment Using ACT – R architecture

4.1 Computing Activation values using ACT-R

This is the process of computing the values of activation. The activation is spread from one cognitive structure to another by their weighting values. [7]

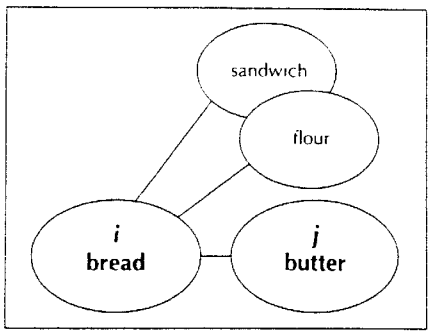

Figure 2. Example for Computing Activation values using ACT-R

Activation of chunk i $A_i = B_i + \sum W_j S_{ji,}$ Where

B_i = Base – level activation of chunk i.

W_j= Activation spread from linked chunks j.

Log likelihood of i occurring

$$B_i = \log \left(\frac{Pr(i)}{Pr(\text{not } i)} \right)$$

Log likelihood of i occurring with j

$$S_{ji} = \log \left(\frac{Pr(j|i)}{Pr(j|\text{not } i)} \right)$$

4.2 Components of the Proposed architecture*:*

Each model of the architecture plays a vital role in E - learning. Interaction module provides an interface between the tutor and the learner where the tutor makes the learners develop divergent thinking, complex understanding etc. [9]. The adaptation model combines all the components of the architecture and interacts with them effectively. This model observes the results from Emotional model and Learning Evaluation Model, identifies the current mood and the performance of the learner. It then changes the mood to active listening mood by modifying the learning content. This can be done by using ACT-R Architecture. The presentation model is responsible for collecting the decisions of the learner and then searches for the best learning object which is present in the LO repository. Also, this presentation model performs communication between system and the course material along with its structure. Then it creates an interface view based on the learning objects. The learner model predicts the basic characteristics of learners and also focuses on informal preferences. The learning evaluation model can evaluate the cognitive psychological support.

The domain model can be used to determine the subject that is being taught to the learners. The pedagogical model determines the method of teaching (activity) by the tutor which will help the learner to enhance their learning. The Emotional model consists of two parts, namely, emotion recognition model and emotion information processing model. The emotion recognition model is mainly used to retrieve the user's facial expression and such information is passed to the emotion information processing model. This model includes facial expression recognition sub model and text recognition sub model. Emotion information processing model finds the right emotion sign from the information provided by emotion recognition model and then predicts the learners' feedback

4.3 Learner History feedback*:*

This component continuously monitors the behavior and activities of the e-learners. Tutors have to find ways to make the learners feel comfortable and engaged. If the learners do not feel comfortable, they lose their interest in the subject. If they feel interested, they can perform to the best of their ability. This can be achieved by continually perceiving their accomplishments.

E-learning for students, is the evolution of technology in knowledge and for periodical review thereof. This concept can be accessed by i) Registration ii) Log-in and iii) Areas of interest, iv) mode of study and no. of switch over between learning material. . The sequential benefits of E-learning are i) Data at the time consumed for learning ii) Online tests and iii) Evaluation of performances. Due to the high quality content created by the tutor, E-learning facilitates tremendous knowledge improvisation. The other incidental benefits are feedback on behavior analysis and focused support in preferred areas of interest.

5. IMPLEMENTATION:

Initially, we compare the existing classroom teaching and E – learning systems developed using ACT – R architecture. Here system software (say) is the subject being taught among learners. We prepare the learning content based on two criteria, namely the content and concept which will remain the same in both the methods with the only variation in the way in which it is presented. The two types of contents are: i) Difficult content and ii) Easy content. The learners are given the option to choose the type of content which they would like to learn. Once the learner completes their lessons, it is mandatory that they attend the test as well. By this, we can examine their level of understanding. If the learners are interested and find it easy to learn, they remain in the conscious listening mode, i.e., default mode is difficult content mode. If they find it difficult or unclear, they switch to easy listening mode. The Proposed system collects the details of the learners such as they switch over between the two different listening modes by their click events and also counts the number of switches from one mode to another. If the system finds that the learners switch to Easy listening mode often, the system modifies the contents to easier and understandable concepts. For example, slow learners who find it difficult in following the difficult content can instead make use of easy content for better understanding. So the learners are first trained with easy content and later with slightly difficult contents, thereby enhancing their ability to switch to listening mode.

Disadvantages of existing classroom (Conventional) teaching:

1. The uninterested learners might disturb the interested learners.
2. A single person finds it difficult in making all the learners to be interested in a particular subject.

Fig3. Depicts the comparative Result analysis between Conventional teaching and Cognitive Teaching. Here, In conventional teaching, We observed the performance of the learner. The average performace was nearly 65%, again we attempted the same teaching in our proposed cognitive learning environment for the same learner. But remarkably the result was nearly 70% by presenting the same learning material in an understandable way.

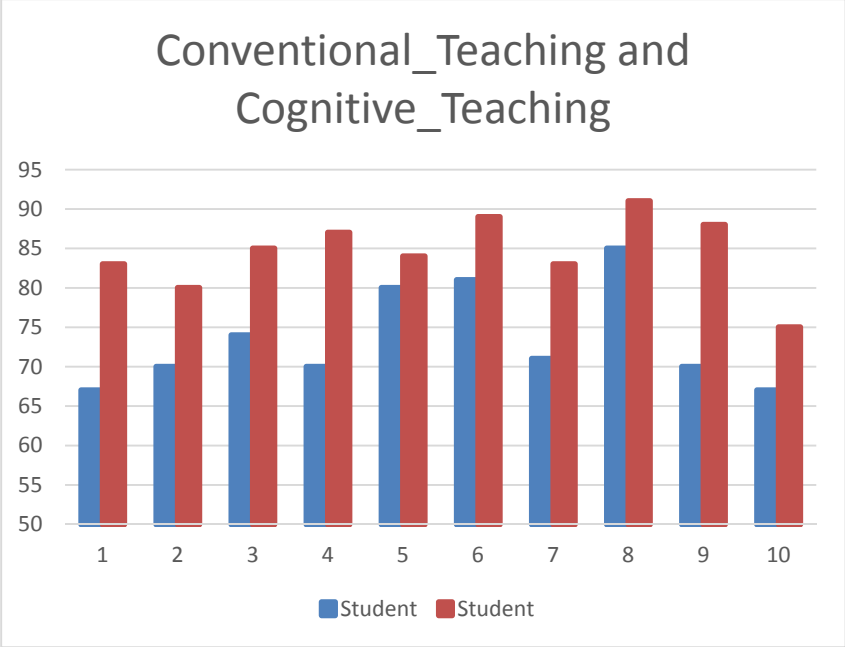

Figure 3: Comparative average Result Analysis between Conventional Teaching and Cognitive Teaching

RESULT ANALYSIS:

A Sample test is performed among the learners using the proposed ACT – R method to analyze `the performance of the learners. Figure. 3 depicts the performance of the learners where the proposed ACR learning is employed. Here the X – axis shows the learners and Y – axis shows the marks secured and mood variation by the learners in several types of modes. Here the main objectives is to make them study and the learner should feel free for this learning environment like pedagogical. If the learner's mood gets distressed due to emotion or uncertain about the subject, then the system divert their mood to licensing mood by dynamically providing understandable learning content. This can be done by opting easy mode. Some learners who found difficulty in learning are engaged in easy mode usually. They are trained in easy mode and their performance also increased. In addition, we observed the individual performance of the learner. The noticeable improvement was obtained [Fig4.]

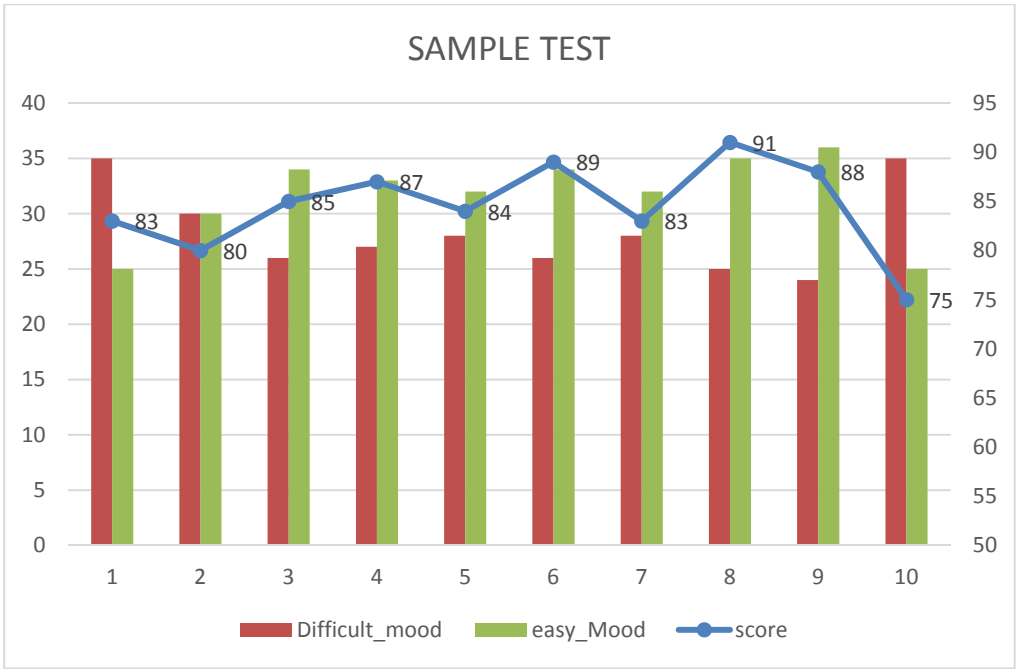

Fig 4. Sample Test

Figure 5, depicts that it is understood that 60% of the students spent their maximum (i.e., 65%) time in easy mood. It shows that starting of e-learning is basically influenced by the good mood of the learner to learn.

Fig 5. Initial mood (Login mood)

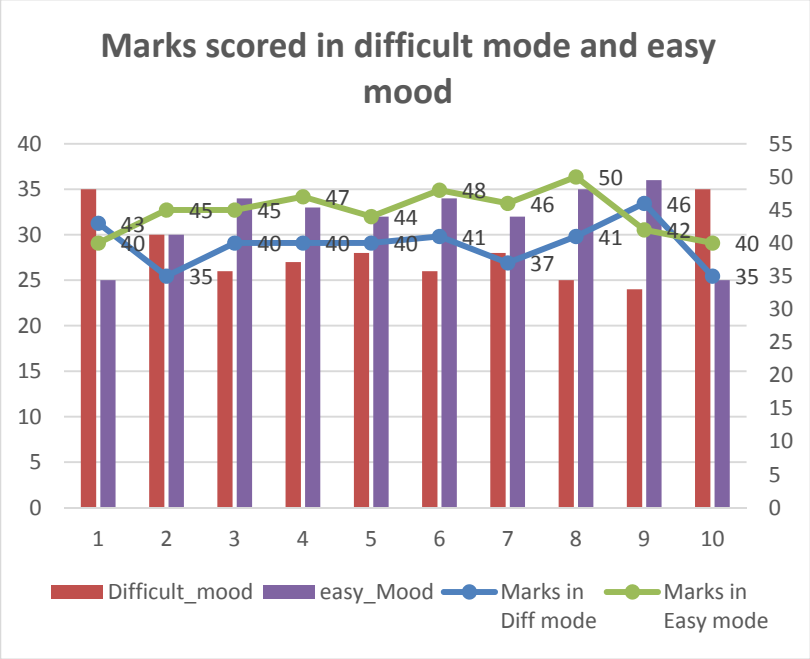

Fig 6. Graph between marks scored in difficult mode and easy mood.

With this graph (Figure 6), it is understood that the average difference between the marks obtained through difficult method and easy method don't have wide difference. Hence it is proof that the cognitive system helps the learner in better learning even during learning in a difficult mood.

Steps:

1. The user logs into the system.
2. By default, the user starts learning the lesson
   And takes tests in difficult mode.
3. If the user finds any difficulty while taking their lesson, he / she will be able to switch to a mode known as easy mode (intermediate kind of listening)
4. There is a counter that will count the quantity of switch overs being performed by the learner.

If the quantity of switch overs is maximized, the system predicts that the learner is trying to improve their knowledge by getting dynamic learning content.

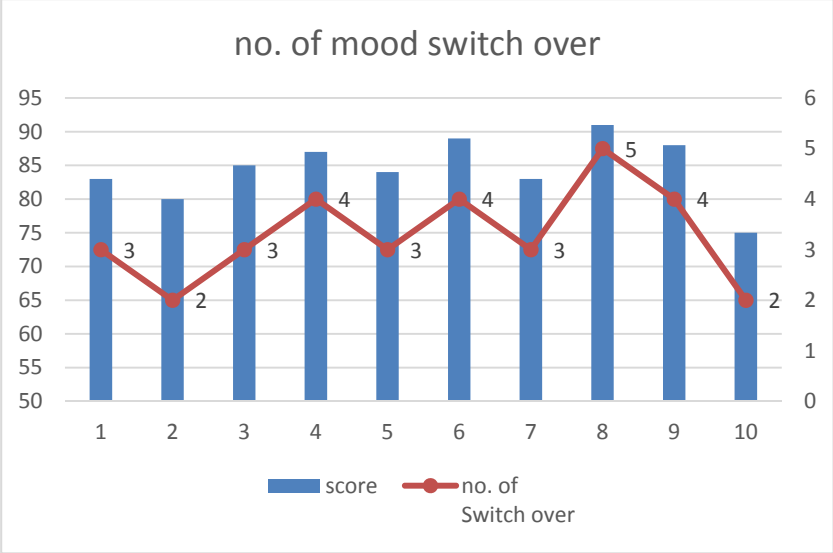

Fig 7. Graph between the No. of switch over and score of the learner.

Figure 7 depicts the representation of dynamic mood switch over. Based on the learner's mood, the system offering the optimum learning content and also we noted the no of switch over .

Since, our system understands the mood of the learner. It adapts and dynamically changed the learning content which suitable for the current mood of the learner. Hence there should be better learning. A better learning should reflect in better scores. Thereby the proposed system enables slow learners gradually to switch from easy mood to difficult mood by improving their knowledge and also the speed of learning.

VI. CONCLUSION AND FUTURE ENHANCEMENT

The existing pedagogical system helps the students to improve their skill and knowledge. Here a tutor handles the entire class and enhances the learner's skills and knowledge. This process makes the learner to be less distracted. So we improve the pedagogical environment using ACT – R cognitive model. The proposed system analyzed the performance of the students by online teaching as well as conducting a test on the subject they have learnt. The students who were above average have good knowledge and their knowledge is improved by the use of this proposed ACT – R. The students who were average, had some distractions and the system helped them improve their skill by offering easy and understandable learning content. Also, the tutors found the learners who were below average and helped them improve their skill by providing an easier content and test. By these repeated easy tests, their performance was improved. Thus, the proposed ACT – R method overcomes the issues faced in pedagogical model and enhances the performance of the learners. This proposed system handles only two moods i.e.. listening mood and non-listening mood but in future we can improve this system by considering more number of moods.

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