Student Centric Virtual Tutelage with Categorization and Progressive Perfection
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Abstract — The purpose of this paper is to suggest efficient alternatives to traditional ways of teaching through application of computational techniques alongside cognitive psychology to categorize students with respect to their level of cognitive competency and then subject them to a teaching model that well suits them in various ways. In education science, typical naturally healthy students are categorized into five ordinal groups according to their level of cognitive competency. The computational techniques which can be used to address each of these levels according to the specific psychological aspects including methodologies, resources and limitations are explicated by this paper. In addition, it puts forth the methodologies of applying above mentioned techniques in different environments under different environmental behaviors such as financial and cultural inheritance. Ultimately, the proof testimonies of concepts that are set forth by summarizing the outcomes obtained from standard statistical sampling and inference.

Keywords — Personal Virtual Tutelage, Computer Based Education, Virtual Learning, Continuous Evaluation

I. INTRODUCTION

Academic excellence is better achieved with student centric education. But capacities of students vary with their levels of cognitive competency. Emotional Quotient and Spiritual Quotient are now being widely used to observe and to identify a person using behavioural and spiritual attributes like attention, perception, memory, learning, thinking, concept building [1] etc. Therefore, the solutions which aim to solve the problems in the education sector must contemplate all the surrounding facts of cognitive science in order to produce effective and complete education experience.

Virtual Reality (VR) is a well-known technology for graphical simulations in a digital environment. Simulation programs are widely used in different contexts in order to reduce the risk and the cost. Immersive VR makes the user immersed in a virtual environment where the real world engagement is unavailable while interacting with the system. Virtual Reality applications that run in desktop computers are generally known as Non-immersive Virtual Reality programs [3]. Graphical processing and audio visual synchronization can be done using a typical personal computer. Interaction with the system of such applications are done with standard input output devices such as keyboard, mouse and display. But in special situations, innovative hardware devices can be used to interact with the system more effectively. Among almost all the devices, the non-immersive VR setup is significantly more cost effective than the immersive VR setup.

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The most tedious task in teaching is identifying the capacity of each student. According to cognitive psychology, accuracy or the grading mechanism is done considering indirect information such as the behavioural measurements inside the class room [1]. Continuous evaluation techniques are used to identify the user by his or her own behavioural attributes which are measured inside the virtual laboratory environment and lab-store. Each student should be well observed in each step inside an educational environment, and they should be furnished with the freedom to work with the exercises of their own. With time constraints and the problem of limited resources in place, it is impossible for any educator to subject students to a teaching model that well suits each student.

Students should be subjected to guidance that can make them reach the highest possible level. Therefore, instruction should be given in such a way to maximize the impact of teaching and the appropriateness of the model. The capacity of students varies with several psychological attributes that could deem their ability.

The paper discusses possible methods of applying principles of cognitive psychology in delivering subject content and mapping teacher: student ratio in a 1:1 manner to maximize individual understanding, thus, achieving the ultimate applicability of principles of cognitive psychology.

II. RESEARCH METHODOLOGY

For the purpose of study, a desktop computer based virtual learning environment was developed for high school level students aged between 16 to 19 years, which will be known as Virtual Laboratory for Physics and Electronics (Ceylearn). Ceylearn was designed in such a way that, to address the issues caused by economic constraints in high school laboratories, for instance: lack of resources and time. All the interaction points of the Ceylearn have followed the guidelines to be used in Cognitive, Affective and Psychomotor domains of the education process (1956, Benjamin Bloom) up to a maximum extent where a computer based environment can generate and execute. A lot of things need to be taken into consideration when an application tries to virtualize a complicated service oriented profession like teaching. The way subject content is delivered, verification of delivered content, subjecting students to categorization and then appropriate training relevant to each category needs to be assured.
A. Factual learning and brainstorming

Factual learning is the process of acquisition and storage of information to be retrieved on demand [5]. Students should recite and summarize information simultaneously. Brainstorming is the best technique to summarize an aggregation and view the bigger picture. In research product Ceylearn, users are presented a main screen where the content and navigation panels have been summarized using brainstorming techniques with colour psychology and colour therapy.

The Ceylearn research product has included a few proximities of contents which have been categorized based on the priority which is expected by the student to be in frequently. As an example, there are two menu contexts which are known as “Practical” and “I’m Bored”. The system needs the student to tend to bend towards the “Practical” section. Therefore the colour themes of two contexts were selected as Green variations and Grey variations. Green is known as the least stressful and most productive in colour psychology [6], [7]. The same result is also significant in a computerized environment. Among the students who were admitted unknowingly to the supervised trial sessions, a significant percentage has selected the "Practical Context" instead of sections which include interesting games etc.

By looking at the big picture, the student will be able to identify the scope and the bounds he or she has to work with. Another important property in brainstorming is that, the user can identify the current level and the amount of content which have been covered up to now. For this, the brainstorm generator module and graphing modules have been used. Organized knowledge content which has been presented in a user friendly environment has increased the productivity and minimized time consumption.

B. Student Categorization

Student Categorization means the task of monitoring student engagement with the computerized environment and storing details of his usage in the database and manipulating the data using statistical and neural networking paradigms to ensure student being assigned to the appropriate category.

Adapting the six levels of cognitive competency in education stated in Bloom’s Taxonomy of Learning Domains (1956, Benjamin Bloom) into a virtualized computer environment would require in-depth application of design patterns and software development methodologies to capture students and then address them for different teaching models based on their current level.

Students tend to learn from their mistakes. But in a typical real laboratory, the trial and error method cannot be applied due to several reasons. Safety issues and lack of resources are the most critical problems. In a virtual environment, students can be provided a safe environment where they can learn by applying theoretical knowledge on experiments to obtain a hands-on experience. By allowing them to proceed with freedom, teachers can observe the creativity of the students without restricting actions due to safety and economical hindrance. But for each and every action which has been performed by students, they are observed by the system and provided appropriate feedback. Real time feedback is the best mechanism to guide the student to prevent the errors and mistakes [10]. For example, if a user violates an initial condition of the experimental setup, the system provides the feedback together with the error and the solution. An intelligent module with pattern classification ability can be assigned for this task. This module should be a neural network based component with optimum accuracy. Accuracy is the most important quality attribute for this module. Therefore, the team suggests adjusting the component to obtain higher accuracy even with reduced optimal performance. A proper thread architecture can solve these conflicts. Since the feedback is provided through a 3D avatar, the level of interaction between the user and the system is impressively increased. This feature mimics real world presence of a lab assistant.

As there are several triggering points (points at which the user’s engagement with the system are manipulated) in the system which will track the user’s interaction to be able to understand the capacity of the user, it is thenceforth easier to manipulate and predict the type of education model that fits him/her the best. Each triggering point and the data collected as the user passes them would let the system categorize the user into three ordinal complexity levels namely beginner, intermediate and expert. Since the psychological concepts behind the manipulation runs are based on six ordinal scales, it makes it possible for the system to group the categories into three two member groups and then name them as discussed.

Even though the real time evaluation is the best mechanism to evaluate the abilities of a person, the paper based examinations have become the efficient and most preferred evaluation mechanism available around the globe. Therefore, the virtual learning environment should secure the ability to prepare the student for competitive examinations. For this, the Ceylearn research product provides a dynamically generated and previously fed question on every attempt of the practical experiment. Remarks obtained for this test would also be considered for the final grade as a weighted sum together with real time observed usage patterns. With respect to the weighted sum, the student will be awarded with a relevant medal to encourage his engagement with the system more in the future. Modern gamification [11] techniques have been used here to enhance the psychological trend towards achieving academic goals.

C. One-to-One Resource Mapping

Since each student’s need in perceiving what is taught completely into their brain is different vastly in variation, it is highly necessary that each individual gets personal attention throughout the course of their education. But it’s also necessary for one to have peer-to-peer engagement to mentally boost themselves to love learning. When the gap between these two different paradigms of education is filled, there would be absolutely no necessity for educators to apply more effort to change the attitude of students toward education. Content -delivery can be made easy and to a wider
population using CeyLearn in an efficient manner that also bridges the gaps between the two different paradigms in educating.

Since individual care for each student as well as peer interaction both are necessary it is only possible in a virtual learning world to overcome all possible hindrance and create a one-to-one relationship between students and all the resources available regardless of the number of student users enrolled. CeyLearn makes it available to users through the nature it was developed. CeyLearn was developed with ultimate usage of the software quality parameter “scalability” to match the real world situation.

![Fig 1. One-to-One Mapping of User vs. Resource in CeyLearn](image)

Figure 1, depicts the internal architecture of Ceylearn. Object Oriented Design Principles alongside software quality assessment parameters like scalability makes it possible for Ceylearn to address problems of any number of students regardless of their current level of cognitive capacity. Inheritance was made use of to efficiently incorporate the six ordinal levels of brain capacity discussed in bloom’s taxonomy into three ordinal levels of scales.[9]

Another object oriented principle “Association” was made use of to ensure the one-to-one mapping between available resources and users which would ultimately make way for personalized education alongside peer-to-peer engagement. Figure1 shows the mapping between the virtual tutor and the user. Same could be followed with all limited resources to ensure that available resources are not exhausted, while not sabotaging the opportunity for students to experience those resources.

The system also lets the student user decide the look and feel of the guide that the system would be building for the purpose of guiding the student. Since user-friendliness is one important feature all learning tools should necessarily have, it’s vital for the option of letting the user decide on the appearance and other parameters like voice that the user thinks is comfortable for him to efficiently learn and develop oneself.

D. Subjecting to Training

Though the paper discusses possible ways of efficiently mimicking the job role of a teacher, it doesn’t completely eliminate the need of a human presence in the learning environment. With Ceylearn efficiently tracking each student and categorizing them, it makes it easy for the teacher to monitor and understand the level where each student stands. System oriented teaching would progressively perfect the skill set each student possesses and the psychology behind it would give the student the right type of guidance he/she requires. Subjecting each user to necessary training also makes the system evolve with respect to the user engaging with the system. Each user profile maintained in the system is a completely isolated learning environment each unconnected to another in the operative perspective and collaboratively linked together in the social perspective.

Profile maintenance and the progressively evolving nature of the system makes it possible to exist as a whole and in isolation at once and make sure that there is personal attention to every student’s educational needs and collaboration amongst students to encourage a healthy competitive environment to map the real world scenario.

Continuous engagement of users with the system through their designated profile brings the system more intimate to each user. The more the user interacts, the more the system learns of the pros and cons and works aiming to rectify and perfect the user as well as the system’s capacity to be the personal tutor for the particular user.

III. FINDINGS, RESULTS AND EVIDENCES

Student centric virtual tutelage with categorization and progressive perfection was implemented, and tested as a research product called Ceylearn, as mentioned above in research methodology. Users were selected using random sampling techniques by assigning random numbers to the students in selected high schools. In order to identify the user experience, two row data types of the selected students are considered. They are non-pre-notified genuine user data which are automatically generated by the system based on user activities inside the virtual environment and the information collected by providing a questionnaire at the end of each trial session. Chi-squared analysis and least square methods have been used to generate summary statistics and inferences.

Ceylearn education model suggests a standardized mechanism for the modern education sector. This model is a combination of existing educational standards and techniques together with latest technology. Likely systems that exist at present provide users with experience one could get in a laboratory in terms of behavioural mapping of equipment. What CeyLearn provides instead is a manipulative system that is able to give users a feedback that is based on decisions made with respect to student psychology.

A. Essentiality of Subjective Training

Most relationships are built on mutual understanding and trust. This phenomenon made it a mandatory requirement for any field that has a significant amount of handling humans to adopt principles of Human Dynamics. One example would be
training involving humans in US Military. Similarly cognitive psychological analysis states reasons as to why it is necessary for any training for human beings to be subjective.[9]

Chi-squared categorical analysis accepts the hypothesis of colour schemes applied in the Ceylearn education model, and is supportive for biased navigation for a virtual educational environment with a 5% level of significance. Biased navigation in the sense, tends the student to navigate towards the classroom instead of games and extra activities.

B. Effective features of continuous evaluation

Identification of students’ level of cognitive competency is a crucial part in the Ceylearn teaching model. Selecting an appropriate optimal feature subset from the total feature domain to train the artificial neural network, can be considered as the most critical subtask of the process. A feature subset is called “optimal” has the lowest dimension while giving the highest rate of recognition simultaneously [13]. By removing irrelevant and redundant features, more performance could be gained without a tiny loss of accuracy or variance. Therefore, an evolutionary method for feature selection based on simple genetic algorithms has been used. The following figure 2 shows the features histogram that has been generated using the collected dataset by trials of Ceylearn research product.

Based on objective functions related to genetic algorithms such as Euclidean distance, Correlation coefficient, Logarithmic magnitude distance, Discrimination cost function and Hausdorff distance, the usefulness of features were calculated [13]. Then the optimal subset of features was used for training, recognizing and comparing the user’s level of audibility. The following are the features which have been accepted as useful for neural network training.

1. Average time span taken to read a word
2. Additional time taken per attempt (in minutes)
3. Number of procedural mistakes done in experiment
4. Number of attempts faced per experiment
5. Score for post-experiment questions
6. Average score per attempt

By considering these features which are harvested at the time of execution, users are categorized into the relevant cognitive level of audibility. For each level of student, there is a specific way to address them. Based on the user level, several content adjustments and behavioural changes have been done. Students with a higher level of audibility are expected to feel that they are inside a laboratory indeed. All the activities related to the experiment should be done by themselves. Therefore, more freedom or lesser constraints are applied on them. The amount of equipment and resources can be used, and the time duration they can spend inside the laboratory is different from a student with low learning skills. In addition, the support from the tutor will be minimized or may be null in the case of students with high audibility. The Tutor’s instructions may not be helpful for a person who works on his or her own experiment. Ceylearn model helps the flow of creativity of students without making any obstacles in all the aspects including environment and psychology.

IV. CONCLUSION

Ceylearn educational model is a student centric virtual tutelage with categorization and progressive perfection. This model is not a perfect replacement for the current education system. But it is an optimal alternative and a helping tool for the current education system which can extend the capabilities of the current system and in addition a prime solution for prevailing problems. The Ceylearn educational model engages in a direct relationship with the four features that define the flaws of the current education system. The methods that have been introduced are applicable for educational environments with basic requirements for non-immersive virtual reality. As a weighted result, 83.9% of all the individuals who faced the trial sessions responded positively for the Ceylearn research product. This is a significant result with regards to computer exposure and mentality of the local high school students.

As mentioned, Ceylearn model is an optimal solution for prevailing problems in the education sector. There are a lot of indirect outcomes which are capable of immensely increasing the productivity in the education sector. First example is the teachers’ record book of students. This record book is the paper based system to collect information about the students of the class room. It is a hard activity for a teacher to observe and identify each and every student and record the report accordingly with accurate conclusions. But using Ceylearn statistics, decision making parties can easily come up with conclusions by the process of psychoanalysis. Because the data generated by Ceylearn model are well organized and focused towards an intended goal, it would be easy for an expert system to analyse the data and conclude important decisions. That reliability is embedded with the Ceylearn research system. The Internal statistics interpreter can be known as another step up to the decision making task done at school or class room level. Even parents who are non-exposed
towards science subjects can easily understand the progress of the child. General summary statistics and illustrations should be used to interpret the outcomes of the internal usage data analysis.

V. FUTURE WORK

Ceylearn research model is an educational model of next generation which has focused on teaching and letting students learn via modern technology in the most effective manner. In the sense of optimality, the variance obtained can be further reduced via two options. One option is to refine the data processing and decision making algorithms and reconfigure the system. The other possibility is to use accurate hardware devices which are verified with higher accuracy measurements and minimal usage time. The latest digital optic devices available in the market for virtual reality like the google glass would be appropriate for what Ceylearn system tries to adopt.

This model is a specific transformation of a natural education process into a collection of computational algorithms which have been implemented and tested through the Ceylearn research product. Therefore, this can be applied for any computational environment (i.e. Desktop Computer, Tablet PC etc.) with the least amount of changes.

Furthermore, it is compulsory to test this model for students from different geographical areas around the world to generalize the concepts and the algorithms. A psychological state of a typical healthy person is likely dependent on the cultural inheritance and other environmental influences around. Hence testing the level of subjectivity of contents within the system with respect to geographical location of the user would ensure the progressively perfecting nature of the learning model proposed by the Ceylearn system. It is necessary to arrange the virtual environment, in such a way as to reduce the number of psychological conflicts between the system and the student’s mind.

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REFERENCES
