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Move to Smart Learning Environment: Exploratory Research of Challenges in Computer Laboratory and Design Intelligent Virtual Laboratory for eLearning Technology

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ABSTRACT

The university's computer laboratory is currently one of the most challenging aspects when imparting practical tasks with regards to the education technology (ET) enhancement. This study intends to observe the issues confronted by students while performing tasks in the laboratory in different educational modes. The online survey is conducted using quantitative and qualitative research instruments to evaluate the students' perspectives. This exploratory work has emphasized the practical issues such as an insufficient time constraint, and instruments, geographical needs, financial concerns, and unavailability of subject specialists to cater for relevant issues about a particular course. The sample size was (N= 161) drawn from a stratified sampling method for analysis of four strata. This research addresses these problems in the laboratory with an aim to improve the student's practical skills as well as their investigation-based learning. It is needed for practical based courses, through experimentation with the help of artificial intelligence (AI) paradigms. The design science methodology is adopted, it presents the conception of an Intelligent Virtual Laboratory (IVL) based on pedagogical agent-based cognitive architecture (PACA). This IVL provides the level of excellence of laboratory needs by enhancing the ET which students can efficiently perform practical tasks online at anywhere. The results showed that IVL has a significant model for enhancing the learning to students and recommendations for further research implementation.

Keywords: human-computer interactions, educational technology, intelligent agent, virtual laboratory, cognitive architecture

INTRODUCTION

Multiple virtual laboratories have been existing through different approaches, and it is motivated that the virtual laboratory (VL) is one of the demanding aspects of spreading learning resources and practical activities of the online education system (Potkonjak et al., 2016; Stark, Bistak, Kozak, & Kucera, 2017). Practical learning is a core of scientific discipline and applied science areas such as computer science, engineering and math. The virtual laboratory can resolve the practical activities in a virtual environment through the adaptive pedagogical methods and students can be more engaged when they build they're own analytical and knowledge skills about practical concepts and demonstrate it in an adaptive learning system (Nye, 2015; Ozana & Docekal, 2017). Frameworks of VL have been ramped up through artificial intelligence techniques as autonomous and adaptive systems in (Nye, 2016; Pinkwart, 2016; Porayska- Pomsta, 2016; Zhuoyuan, Lingong, Ping, & Yigang, 2017).

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Contribution of this paper to the literature

- This paper presents proposed pedagogical agent based cognitive architecture (PACA) which is constructed based on the unified theory of cognition for designing Intelligent virtual laboratory.
- It has evaluated existing services of computer laboratory work through online surveys that enhanced students learning in their practical courses for examining the students' issues faced while using computer laboratory in mode wise education.
- Agent based use case modeling used for IVL system that has represented external actors and internal actors of system functionalities.
- Design and development of programming course laboratory HCI, interfaces as a case study for evaluation.

Cognitive architecture (CA) has been designed for accessing different sources of cognition from the theory of intellect, and its behaviour has been summarized through cognitive psychology. Cognitive psychology deals with the processes, retrieval, and warehousing of human knowledge mind structure. The behaviour of different modules of mind has been implemented in a computer model for building agent behaviour and structure (Langley, Laird, & Rogers, 2009). CA supported the active agent's behaviour from the accessibility of knowledge acquisition such as SOAR (Lehman, Laird, & Rosenbloom, 2006), ACT R (Anderson, 2005), BICA (Samsonovich, 2012), IDA, and LIDA (Franklin & Ferkin, 2006) architecture.

The hypothesis is that a learner can interact via the Cognitive Learning Management System (CLMS), which can be guided and monitored by a pedagogical agent based on cognitive process modules. The pedagogical agent can always be available to cater learner needs and to dissolve the student troubles, e.g., Regarding programming and architecture courses in VL environment. Likewise, it can likewise be applied to different cybernetic applications which can raise the learner's cognitive ability virtually, such as a war college's practical task. The proposed research described that intelligent laboratory companion (ILC) based on CA which can be employed as a research lab assistant that has the ability of self-regulating learning to aid pupils in practical tasks of computer skill.

Many artefacts have been constructed from the model of the human mind such as self- regulation ability (Samsonovich et al., 2008). The agents put up be used CA to assist and enhance the learning motivation of pupils. Furthermore, there exists a growing need for an adult conceptual understanding of science teaching. In the proposed architecture, E-Laboratory environment has contained semantic memory, procedural memory, graphics, and a text-based interface. ILC can interact with E-Laboratory interface that includes the mechanism of short-term memory, episodic, and associative memory. The E-Laboratory interface demonstrates an innovative platform that communicates with ILC controlled by a mouse, a keyboard, and a graphical user interface event manipulation. ILC can be supervised and conducted by cognitive abilities such as perception, attention, a long-term and short-term memories, judgment evaluation, and knowledge management. ILC as laboratory assistant can assist with whole steps of the student performing practical tasks during the lab session. The jobs can be apportioned according to knowledge and the difficulty level of the pupil. The agent responded, according to perceptions about a learner mental state and acted upon by procedural memory. All steps of learner perform semantically, which is responding to agents monitoring.

This research addresses the problem that how can we improve students practical skills and investigation based learning which is associated with different disciplines of science and engineering, through experimentation and demonstration in Intelligent E-Laboratory environment. The IVL can monitor and guide of every step of learners using multimedia (text, audio, and video). The following questions have formulated.

RQ1. How can we evaluate that the existing services of computer laboratory work has enhanced students learning in their practical courses for examining the students' issues faced while using computer laboratory evaluation in mode wise education?

RQ2. How can pedagogical cognitive architecture be constructed by proposing a unified theory of mind?

RQ3. How can we enhance students engagement through E-Laboratory in CLMS to be useful for practical distance learning courses?

To answer these questions, in parliamentary procedure to improve the practical skills and investigation based student learning, PACA has been projected and constructed according to a unified theory of judgment. This cloud-based VL application environment can be produced such that students can access, be engaged for better understanding, and live up to the demands of enhancing the practical learning courses with ILC functionality. The experimental results have been analyzed with IBM SPSS 19 which showed significant results regarding IVL usability and learning of basic concepts of programming for the enhancement of student learning.

This paper is organized as follows: The motivation of the intelligent virtual laboratory and research questions have been described. Section 2 is an overview of the cognitive architecture domain and their relevant projects. Section 3 provided the detailed analysis of design methodology and the proposed architecture. Section 4 provided the design and development of IVL. Section 5 presented an evaluation summary. Section 6 presented conclusion and a future direction of this domain.

LITERATURE REVIEW

CA is the scheme of mind architecture for building the intelligent system. It has included all aspects of cognitive modules for performing activities which are based on planning, logical thinking, problem-solving through learning and experience. Different memories have been involved in the processing and storage of knowledge, such as a short-term considered as temporary memory storage for a short period of time and a long-term memory as permanent storage for an extended period of time. The long-term memory has further split up into explicit and implicit memory. The explicit memory has involved episodic and semantic memories. The Implicit memory has involved procedural memory. By contrast, Knowledge-Based System (KBS) has used inference rules to decide which task level to launch. Allen Newell explained twelve main criteria for the rating of cognitive system's behaviour by unified theories of cognition such that behaviour can be adaptive, dynamic, and compromising. Natural language processing (NLP) has used for interpreting the operation of a complex adaptive system (Duch, Ontario, & Pasquier, 2008).

The information and communication technology are developing quickly to improve the productivity of the country economically for forming a digital solution which is provided with any software or hardware system application. Communication, and information technology services have been used in different disciplines such as teaching, research, eLearning, digital libraries by utilizing these telephonic, audio and video broadcast network technologies (Luo & Bu, 2016). Researcher in computer science and AI are investigating and developing educational support for a growing educational technology by proposing a pedagogical framework (Pinkwart, 2016).

Assessment of learners has been grounded on different learning models, such as a SMILI framework, which provided the comparison between open learning models (OLM) (Bull & Kay, 2016). Architecture Extensible Problem-Specific Tutor (xPST) also empathizes on computer-based command and provides customized hints using the generation of the error message (Gilbert, Blessing, & Guo, 2015). The Lab4CE model has introduced the environment for computer training students who experience difficulty in networking subjects (Broisin, Venant, & Vidal, 2015). It has likewise brought in a model to predict a student's knowledge and showed the dialogue between the pupil and the computer-based tutor. Deep Tutor projects are operating on a macro and micro adaptations by proposing the framework (Rus & Stef, 2011).

The practical activities in online education in different domains of scientific discipline and applied science have investigated, to be offered to distance learning and blended learning students through a distinct prospect of the framework or techniques (Broisin et al., 2015). There is a need to generate new knowledge from existing knowledge for enhancing the quality of the distance and blended education by the intelligent agent evolving to deal laboratory works of huge strength of science and engineering students. Samsonovich presented the cognitive constructor which was founded on a GMU BICA cognitive architecture for modelling self-regulated problem-solving skills enables students to develop self-regulation skills for mathematical problems (Samsonovich, Kitsantas, O'Brien, & De Jong, 2015). It has focused on the blended education through a virtual and remote lab for undergraduate and graduate teaching in the different field of biotechnology and biomedical engineering (Diwakar et al., 2016).

After the analysis of literature, we have noticed that recently many researchers from different domains are running on a virtual system to offer the best result. Therefore, it is time to bring forth new knowledge from the existing one by using the blending field of the unified hypothesis of mind for quality and enhancing the practical study of distance and blended training. A better understanding of science concepts and performing practical tasks efficiently anywhere on cloud web services to guide learners according to their knowledge level. The proposed prototype solution integrates and combines the approach of different fields such as computer technology, cognitive psychology, AI, education technology and human-computer interaction.

RESEARCH DESIGN AND METHODOLOGY

The methodology followed during different phases of the inquiry which has quantitative, qualitative, applied, and experimental research. During literature surveys and system design phase, the qualitative methodology has used involving research tools such as expert interviews, surveys, and observation. The design science research (DSR) (Vaishnavi & Kuechler Jr, 2007) methodology has taken over for achieving the objective of prototype solution. Taken into account the research questions through DSR approach, our actions have been divided into following: firstly, problem identification and the motivation phase for thoroughly investigated and formulate research questions. In this phase, an initial investigation has been taken via an online questionnaire. In the second phase of prototype design and development, PACA has been constructed based on a unified theory of mind. The cognitive framework to be acquired based on an Agents methodology for virtual knowledge sharing to contribute in a virtual

Table 1. The mean, STD-deviation, Std. Error of Mean and variance of sample size

N	Valid	161
	Missing	0
Mean		1.90
Std. Error of Mean		.085
Std. Deviation		1.079
Variance		1.165

Table 2. Stratified sampling method

	Stratum	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Elearning (online education)	76	47.2	47.2	47.2
	Conventional (live classes)	51	31.7	31.7	78.9
	Blended (online mode as well as live classes)	8	5.0	5.0	83.9
	Distance learning	26	16.1	16.1	100.0
	Total	161	100.0	100.0	

HCI environment. The aim is for the student gaining and enhancing practical skills as per conventional mode of practical work assigned to the students.

COMPUTER LABORATORY EVALUATION QUESTIONNAIRE

The purpose of this survey was to understand and evaluate how existing services of computer laboratory work are enhancing student's learning in their practical coursework. The student's answers were helpful in improving computer laboratories for better understanding and learning experience.The data collection method of computer laboratory evaluation questionnaire was drawn on both quantitative and qualitative wise. The qualitative data were also analysed to overcoming the student's problems and get ahead to further enhancement and understanding of students' views. The questionnaire has been distributed to students via online as shown a web link in **Appendix 1**. The questionnaire was composed of 37 valid questions which included closed as well as open-ended questions. It has a combination of Nominal and Ordinal type data.

A Stratified sampling method has been employed for sampling. We have four strata of estimated heterogeneous population L = 4, such as conventional, eLearning, blending and distance learning institutions students in rural areas of Punjab. The sample size was N= 161 for random sampling of giving strata. The total target population of the survey was an estimated figure of conventional, eLearning, blending and distance learning institutions, students who were graduate of computer science project disciplines in spring 2017. We have selected homogeneous random sample of N1=76, N2=51, N3=26, and N4=8 from eLearning, conventional, distance learning and blending institutions respectively.

Table 1 shows, the output of IBM SPSS Statistics that describes the mean, standard deviation and STD. The mean error of sample and **Table 2** describes the frequency and percentage of data from each stratum.

DATA ANALYSIS

The mixed method is employed for data analysis which holds 62 % quantitative analysis based closed-ended questions and 38% has a qualitative study based open-ended questions. The Qualitative data was encoded and sampling using a thematic analysis approach (Guest, MacQueen, & Namey, 2011) through MS Excel. The actual qualitative data of first 15 examples of quoted responses from students (the respondents) as shown in **Appendix 2**. The Statistical analysis has been carried out in IBM SPSS Statistics 19. This survey has been targeted to computer science students who have attended the computer labs for their practical courses.

The demographic data of participating students indicate that 36% were female and 64% were male, which has linked to postgraduate students that were 45% and rest where the undergraduate level enrollment. The survey was circulated online to different universities in multiple areas of Punjab, Pakistan. The majority of students participated were 47% who studied in eLearning mode of education; others were 38% from the conventional mode, 5% of blended learning and 16% from distance learning institutes. The other 85% students were assisting the computer lab in our university, but not frequently and 14 % were not attending due to time constraint issue because they were also job holders and were performing jobs at morning time. The majority of students (55%) of the population were attending the labs for programming courses.

When we asked about, are you satisfied with the instructions provided for the lab work are enough to accomplish your lab task/s work: 57% had satisfied with enough instructions provided, but 34% students had

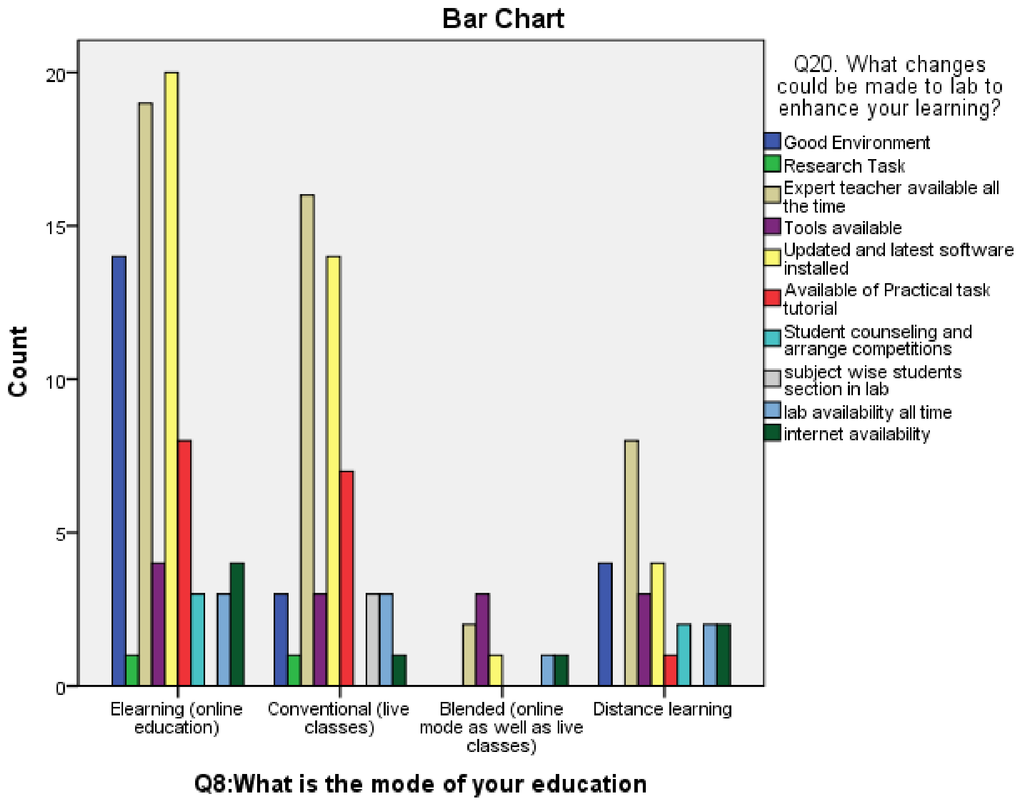

Figure 1. Crosstabs between Q8 and Q20

average responded, and 7 % had dissatisfied their instructions. Almost 57% students have a high ratio responded about How much you have learned about course concepts from the lab, and 26% have a medium ratio, and 15% have a low ratio responded. Students answered the lab environment, instructor guidance, friends or group discussion, lab Management were responded by asking which aspects of the lab were most valuable to your learning. In open-ended questions, have analysed using a thematic approach such as when asked around what modifications could be caused in the lab to enhance your learning: the sample of students have found a response that correlation between modes of education wise by crosstabs statistics represents in a bar chart as presented in **Figure 1**.

The majority of students have responded about asked which types of problems you have faced while problem-solving of the assigned task represent in a pie chart as shown in **Figure 2**. The students have answered regarding which types of parameters should be implemented in lab work as shown in **Figure 3**. The majority of students (69%) was agreed that without lab work, we could not understand all concepts of practical courses and some groups (12%) were yes and the rest (18%) may be responded. The pupils were positive responding (55%) about asking regarding Mostly, lab assistant is available when need their guidelines: some groups (12%) were a negative response, and 31% was a response that sometimes available. The average students (43%) were satisfied with the overall quality of the lab equipment's, 45% were satisfied and 10% students dissatisfied responded. The most responded regarding "How often do you use computer laboratories on your campus", 11% were never used a computer lab on campus. 16% were employed less than once a month. 13% were used once or twice a month. 16% were used approximately once a week. 42% were using Several times a week. The frequency responses have received from students regarding instruction/assistance that is needed while performing practical tasks in the lab or on your home computer that was analyzed by thematic approach as shown in **Figure 4**.

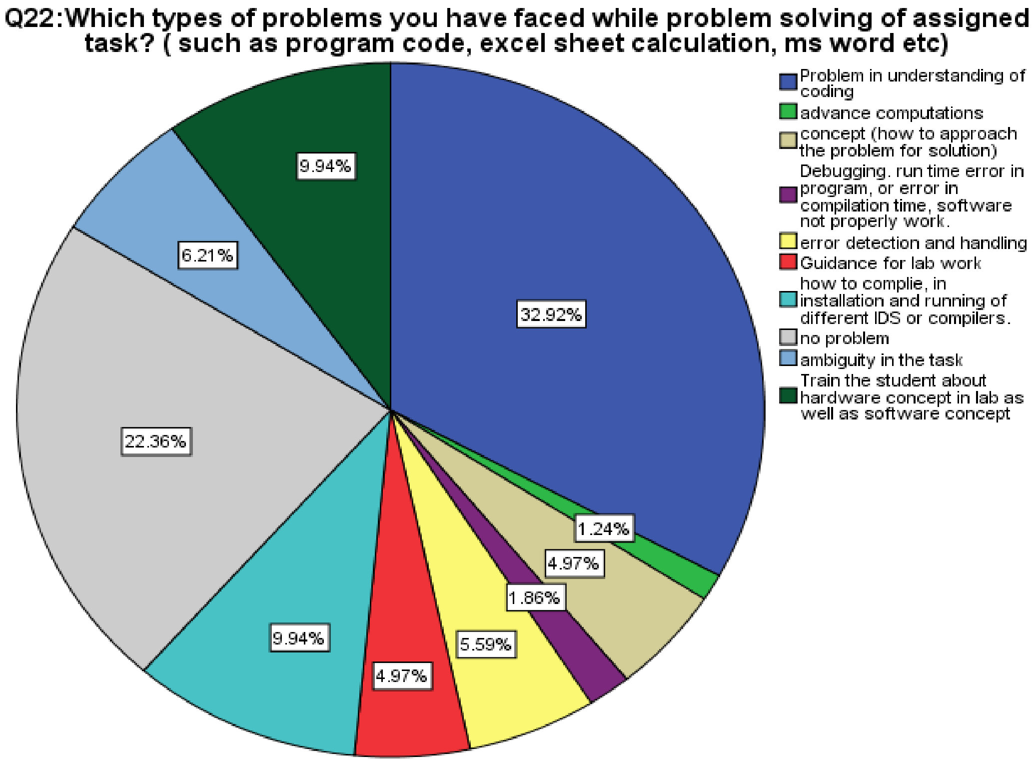

Figure 2. Frequency of students responding to a problem faced in the assigned task

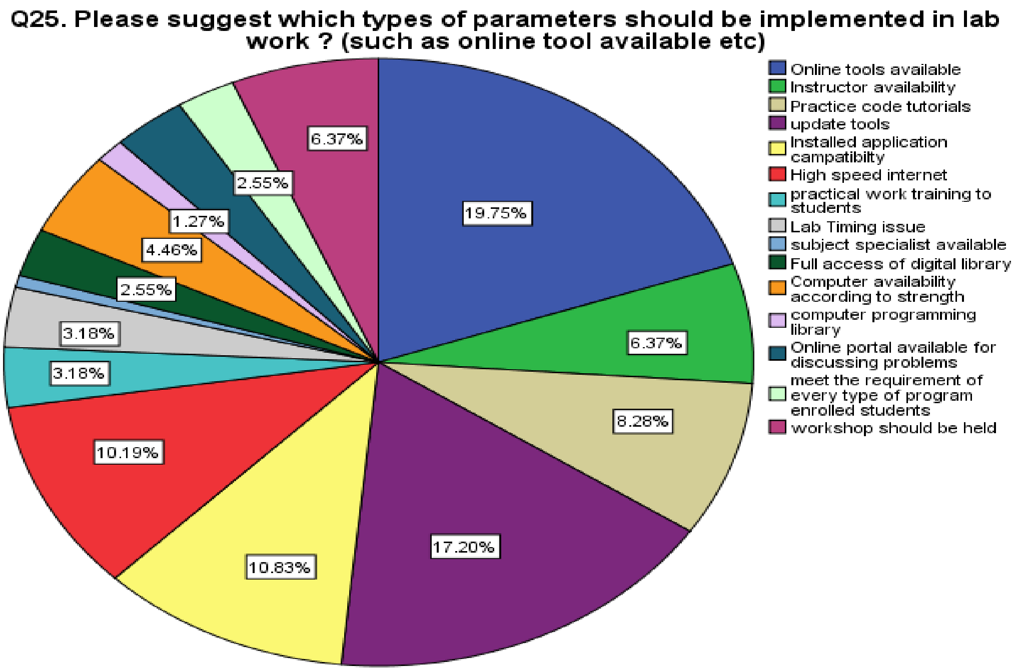

Figure 3. Pie chart regarding parameters suggested by students

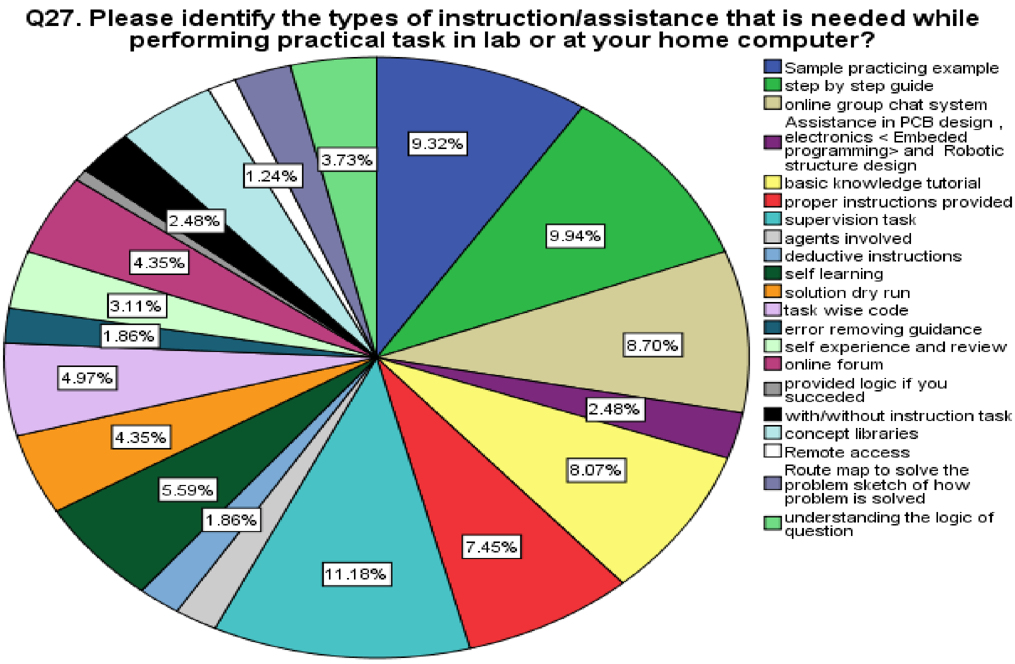

Figure 4. Students responded regarding instruction required in labs

CHALLENGES ALLIED WITH DESIGNING AND DEVELOPING AN INTELLIGENT VIRTUAL LABORATORY

The Challenges associated with planning and developing the intelligent virtual laboratory as perceived by the students, which have participated in the survey. The challenges faced by computer science students while performing the task in the physical laboratory such as some examples of quoted responses from students (respondents) in **Appendix 2**. There are some comments illustrating the challenges of Technological enhancement of laboratory tasks as perceived by the research participants. Those measures are Latest Scientific deviations, software problems, curriculum changes, student competency, equipment failure and software inconsistency, lack of communication between expert teachers according to particular course wise. Further, these are Lack of adequate training for students, didactic instructions, group discussion platform, laboratory time clash issue, programming incompetency such as a problem in understanding of coding, advanced computations, concept understanding (how to approach from problem to solution, Error detection and handling especially logical errors. We have to overcome those challenges faced in the physical laboratory and proposed the solution of the intelligent virtual laboratory that can be employed to overcome these encounters.

PROPOSED PEDAGOGICAL AGENT-BASED COGNITIVE ARCHITECTURE (PACA)

The primary focus has designed on PACA (Munawar, Toor, Aslam, Enriquez, & Hamid, 2017) for the virtual laboratory by proposing the unified theory of mind, according to metaphysical, cognitive psychology, neuroscience, philosophy and AI theories. The design of a laboratory has built according to the objective of research and implements the idea of cognitive modules such as sensory memory, perception, working memory, attention, and action selection based on declarative and procedural memory. The cognitive cycle of a virtual laboratory primarily involved these modules and acted upon according to the cognitive processes of short term and long term memories as shown in **Figure 5**. The PACA has divided into following three layers based on cognitive processes as depicted in **Figure 6**. Cognitive modules within each layer work as information processing, which is being perceived, retrieve, restored, recall, and encoding as in a formulation of the human brain. The focus of research is to develop the CA-based agents that act and behave like a cognitive cycle in human mind simulations. It has too performed the part of different modules of the cognitive process unit. The first layer has a virtual environment which has included a web interface for graphical user interface (GUI) of the intelligent virtual laboratory, sensory memory and actuators. The second layer has included perception and action selection modules.

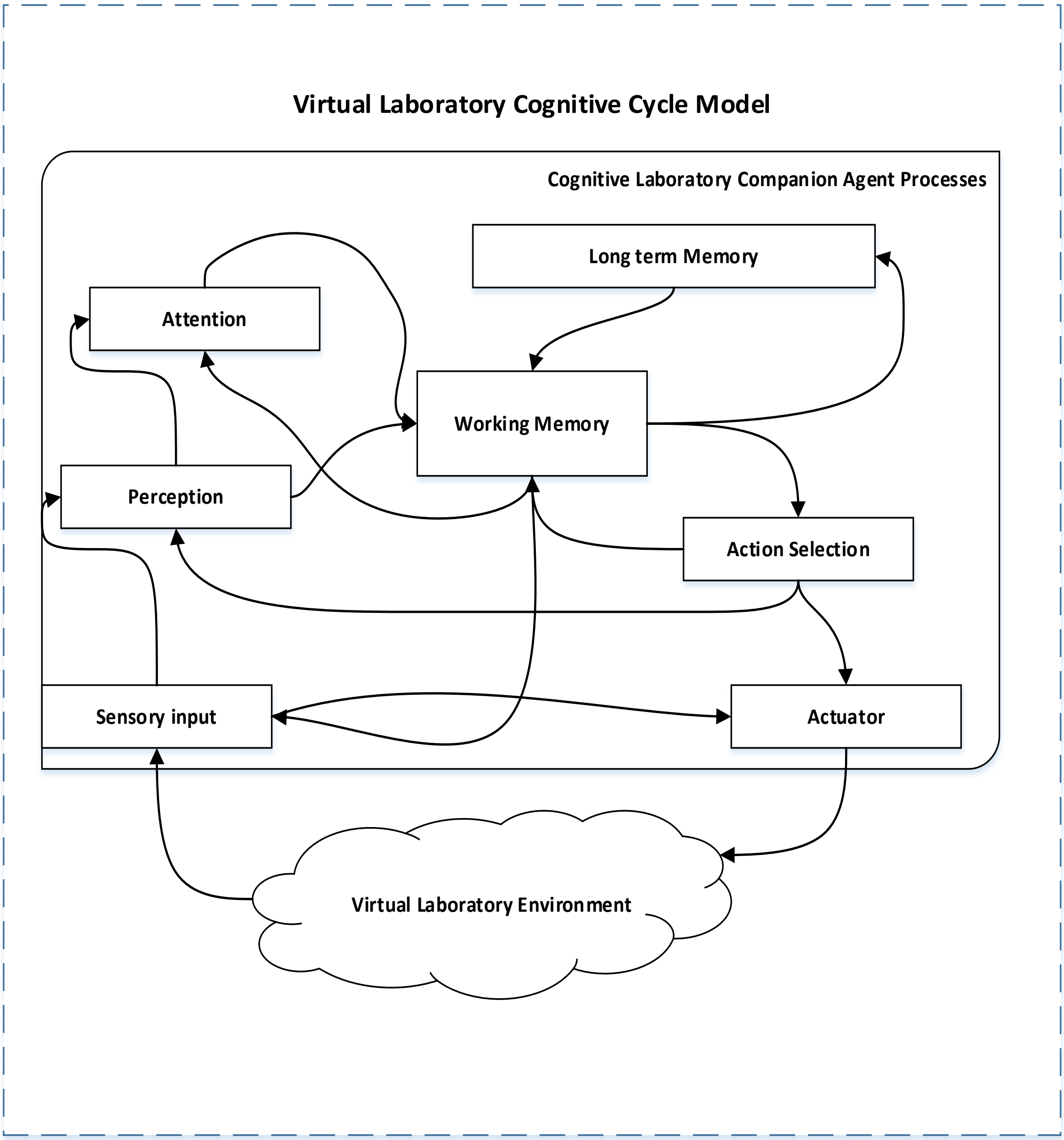

Figure 5. Abstract level Cognitive Cycle Model for Virtual Laboratory

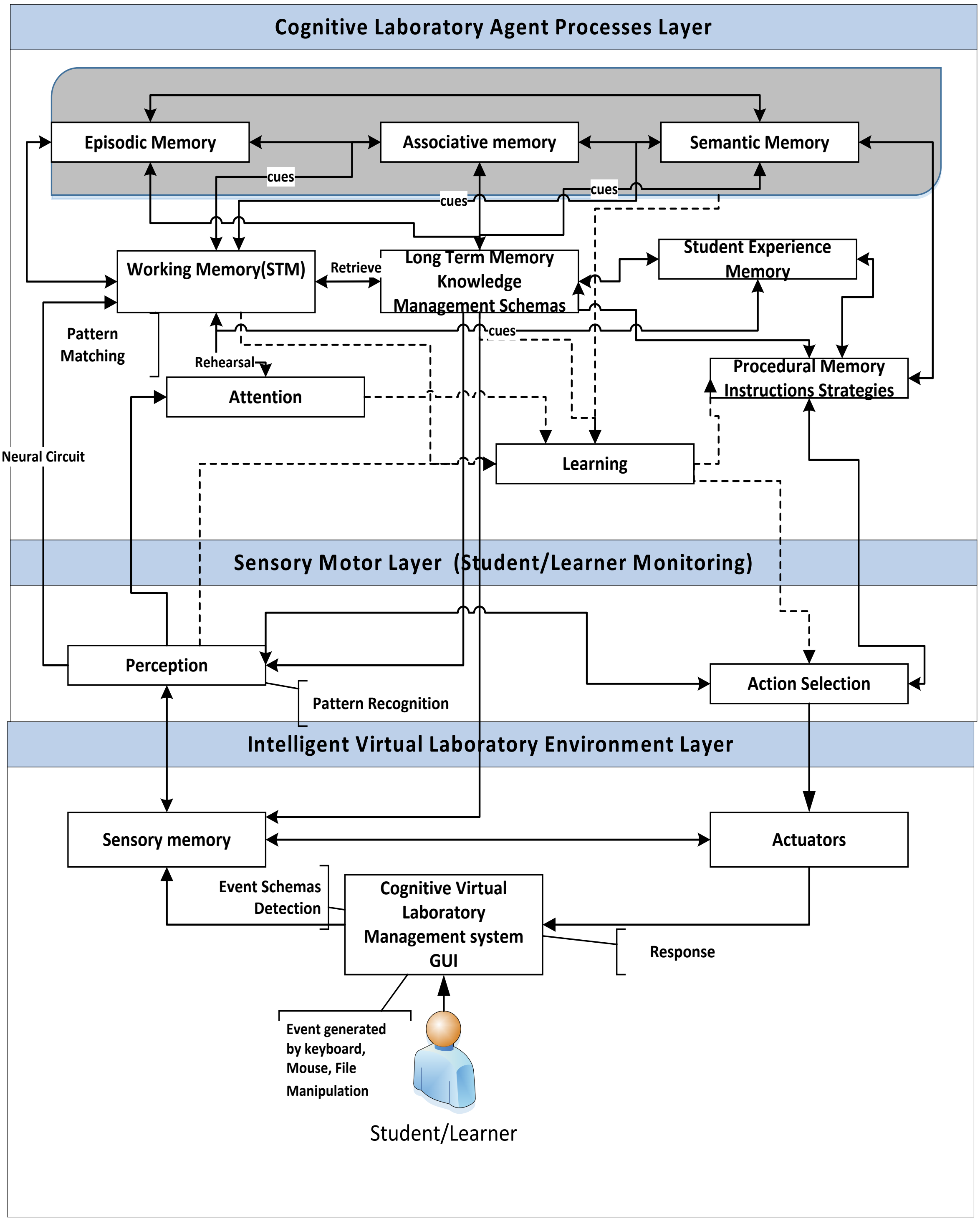

Figure 6. Pedagogical Agent-based Cognitive Architecture for IVL

The third layer has included cognitive agent processes such as attention, working memory, long-term memories and learning modules. The details of each of these layers and their cognitive modules have discussed below.

VIRTUAL LABORATORY HCI ENVIRONMENT LAYER

The students interacted with the GUI of the cognitive virtual laboratory environment and performed the practical task according to the given scenario. The event-driven schemas detected on the interface by the sensory memory via manipulation of a keyboard, a mouse and file manipulation events. This module has connected with perception and actuators.

Sensory Motor Layer

Perception modules take information from the sensory memory and send to the attention memory for attending events. The encoding process has taken up by recalling the procedure of operating memory. The perception, memory has assigned meaning to object incoming events and the combination of objects such as contents, and so on. The perceptual learning recognized the new objects, relationships and categorizations of objects through the complete one or more cognitive cycle for pattern identification. In this layer have involved cues of working memory, declarative long-term memories, procedural memories, and action selection.

COGNITIVE AGENT PROCESSES LAYER

In this layer, some events have been detected through the attention mechanism for incoming perceptual objects. The effect has been selected the relevant case, action during a single cognitive cycle or multiple cognitive cycles which connected to working memory. The event conditions can be recalled, matched, and encoded to search material in working memory. The cues have been retrieved from long-term memory. The conditions or rules or knowledge schemas have resided in long-term memory which retrieved from short-term memory for a pattern matching and recalling the event. These actions have been performed in multiple cognitive cycles in seconds. The knowledge that has most relevant to the current contents have held in working memory. Short-term retention holds a temporary memory that controls all the contents of currently executed working processes. In contrast, long-term memory has a permanent memory which further divided into explicit and implicit memories. The explicit memory has included an episodic memory which has lodged in the student's current events. Semantic memory has schemas for a categorization hierarchy of event objects and their relationships. The implicit memory has included a procedural memory which performed a task according to experience skills with the number of cycles of learning mechanism by action selection. The long-term has interacted with episodic memory, associative memory, semantic memory and student experience memory. The action selection has performed through procedural knowledge, instruction strategies. The procedural rules of contents have been executing behaviours using deep learning to deliver a new result or to improve the performance of existing result. The continuous cognitive learning cycles have been started from perceptual learning to action selection for practising and improving the experience with the help of neural circuits.

DESIGN AND DEVELOPMENT OF IVL

The Intelligent Electronic Laboratory (IE-Laboratory) system was designed according to the learner/student requirements of training/practical work. The project has allocated according to an eLearning student's knowledge level who aware of a virtual environment and who covered stages within time. The system provided the tasks and manage activity, according to student knowledge and difficulty levels such as how to complete the task within given time period and how many stages are covered with the help of hints, event handling, delay, a lesson, and tutorial visit. The performance measures according to completion task processes. The ILC responds according to perceive learner/student mental states and act upon it by procedural memory through actuators. It has monitored every step of learner semantically and responded to it. The IVL meets following the functional and nonfunctional specification.

The general functional specification of IVL and their roles act upon it. The system has a GUI of CLMS which have apparatus and practical instrument objects for practical courses and manage sections in multiple task stages. It has roles such as laboratory administrator, lab instructors, ILC, and students. It has provided a login page so that students can log in, the system using their assigned university ID, password and have access according to assign rights. It has provided the initial assessment task for performance measurement of knowledge and the difficulty level of students. The system automatically a generated log of student task completion and upcoming laboratory tasks in episode wise. It has provided the list of practical courses from computer science domain (anyone, e.g. Digital logic design, computer programming, networking, and so on). It has intelligent experiment an interface which has practical laboratory course materials, task procedure, and topic contents. It has provided under the selected practical course: the introduction, experiment lists of topics chosen, process of performing experiments, tutorials, and reference materials. It has provided the simulator and an animation interface for doing experiments.

The system provided the online assessment after attempted experiments and automatically saves the students' activity records in each session while performing a practical task. The system has some laboratory companion agents who monitor the activity of students by event schemas in laboratory sessions. The system has been designed neural machine states, according to the student's mind by proposing PACA as shown in **Figure 6** and measure the path of student activity and ILC performance. The ILC agents can sense and perceive the student activity. The ILC responded and tracked the student action, granting to a long-term and short-term storage. The ILC can adapt, learn and guide the student according to student experience memory. Laboratory administrator has viewed the performance of both ILC and student's activity and published the reports as well.

The Laboratory administrator has viewed and handled the course administrator, instructor and ILC. All students can view their position in the practical laboratory session and also showed the covered task at completion level. The pupils have access to different resources related to each laboratory task semantically. The system has provided a glossary of the terminology used in the virtual laboratory according to event schemas. The students have organized to work in groups as in conventional study and be able to communicate with each other and share resources in a cloud environment. The student was able to locate and search the appropriate resources efficiently. The student can able to ask questions to ILC during a laboratory session. The students can save the laboratory session in a cloud web environment and maintain the e-practical copy of practical courses. The system maintains the experience of students in episode wise. The ILC was able to take out the learner's study progress and grade report. The teachers can create learning scenarios. However, students have used and followed learning path. The student has access to log in for utilizing resources according to complete the tasks in stepwise. Several login options have also offered depending on acceptable privacy levels and successful completion of task stages. Course administrator, teacher, and students can tag, comments and rate laboratory. The courses have been designed according to program wise and student's performance measured while conducting experiments.

The nonfunctional specifications have also affected the design of cloud-based IVL, such as IVL system has easy to use, which often included how easy it is to learn according to a level of the student such as graduate and postgraduate level or researcher. The (IVL) system has designed and developed using MVC architecture, C#6, HTML5, CSS, jQuery, AJAX, bootstrap with entity.net framework and scratch programming. The system can work and collaborate with other systems in a virtual environment, e.g. LMS, CLMS and so on. This research is beneficiary for those sectors such as education Institutes (distance learning and blended learning), a computer scientist for applying education technology and AGI research, AI industry for mass production of a system, the education sectors such as school, colleges, university system for scientific and engineering practices work.

AGENT BASED USE CASE MODELING FOR IVL

The functionality of the IVL system has represented in agent-based use case modelling, which has included external actors and internal actors of system functionalities as shown in **Figure 7**. The IVL system has interacted with external actors such as lab administrator, lab instructor, and students. ILC agent's performance has involved internally as an actor. The lab administrator has managed the laboratory and lab instructor. The lab administrator and lab instructors have managed the student activity registered id wise with the help of ILC agents. It has also managed performance and announced the result criteria. It has as well managed and watched all the agents' activity performance.

The lab teacher has brought off the courses and experiment banks, which own a platform linked to each course wise. It has done the course report with the help of ILC agents. Pupils accept the choice to select the practical training session and the practical monitoring session. The student interacts only with a practical coaching agent in training session. In monitoring/performing session, it has interacted with all generalize agents of ILC agents. Initially, students have given a pre-assessment test for performing course experiment. Six generalize agents have required in the system. Such as agent1 has performed the practical interaction and coordination. Agent 2 has performed duty as a practical dispatcher agent. An agent 3 has performed practical coaching. Agent 4 has performed duty as a practical expert agent, Agent 5 has supervised the practical knowledge management, and agent 6 has performed duty as a practical inspection agent.

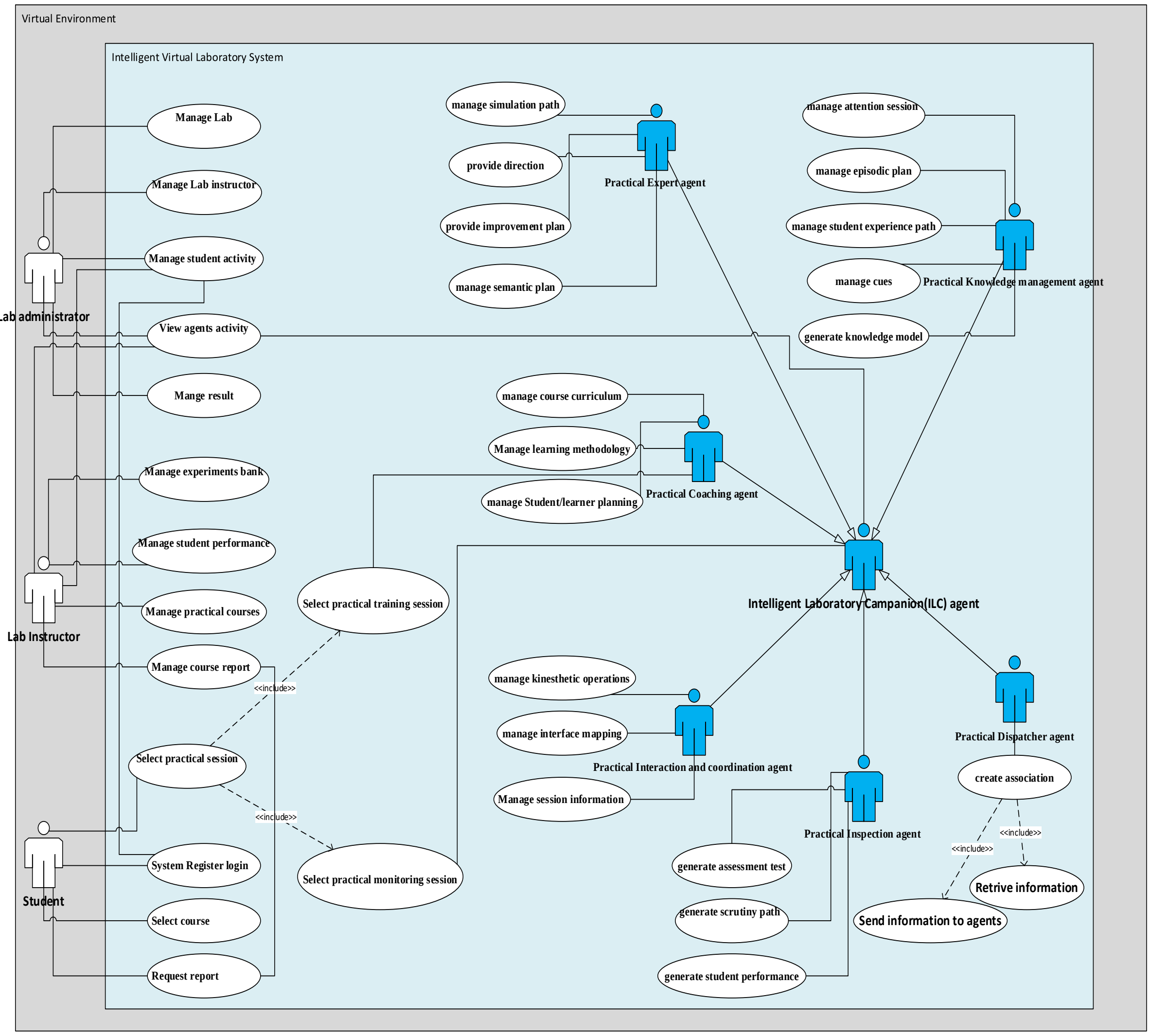

Figure 7. Agent-based use case modeling for IVL

DESIGN AND DEVELOPMENT OF PROGRAMMING COURSE LABORATORY

In HCI design interfaces, IVL has multiple practical courses available for laboratory tasks as shown in **Figure 8**. The functionality of a programming laboratory as shown in **Figure 9** which have a relevant glossary related to the topic available on the left side of the lab. The student firstly has dragged these terms and perform the task for assessment given by an inspection agent. All agents had active and monitored the activity of the student. When a student has interacted for performing lab session, agent1 has managed the kinesthetic operations, interface mapping and session information. Agent 2 has performed and created the association between all agents' activity, e.g. Sending and retrieving the information from the agent 1 to the agent 3. The agent 3 has managed all coaching activity of students such as course curriculum, learning methodology, and planning of student learning. The agent 4 has managed the improvement, simulation, direction and semantic plan.

The agent 5 has managed all knowledge management activities such as attention session, episodic and experience planning, cues and generated the knowledge model. All assessment test managed by agent 6 and generate a scrutiny path for performance evaluation of students. When students have tried the wrong term use of the platform, the expert agent is set off the message for correcting the action and end product is generated by sampling it again a message. If the student still is attempted mistake, the coaching agent is appeared for one time coaching on the subject in a monitoring session.

Figure 8. Multiple Practical courses and relevant topics available in IVL

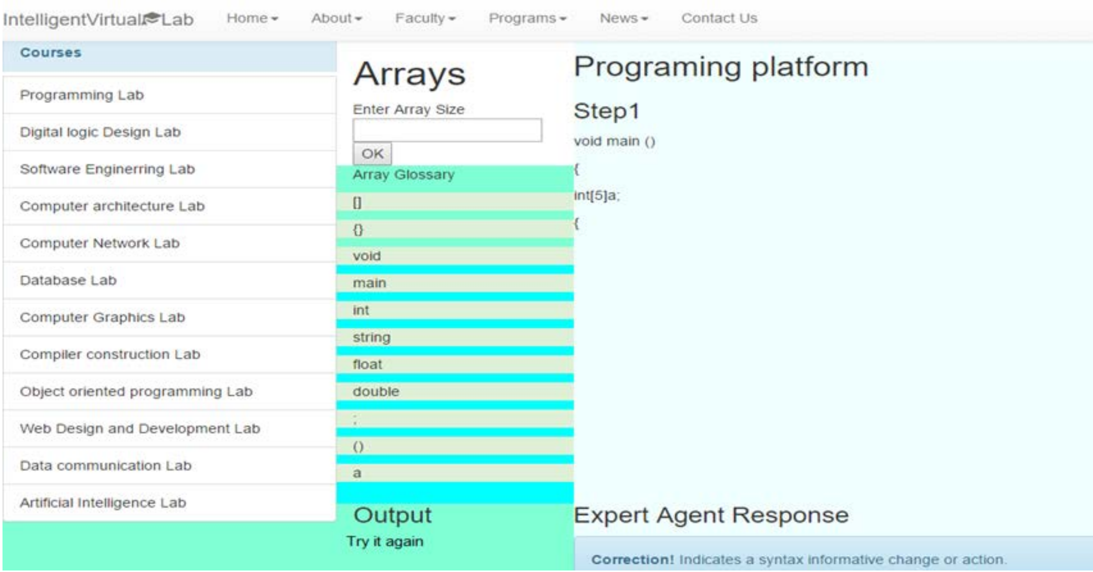

Figure 9. Programming Laboratory Interface of IVL

EVALUATION SUMMARY

It has presented the evaluation of IVL for specific programming concepts. It had the conducted initial level investigation based on questionnaire survey for evaluating the students' performance after using the IVL experiments and analyzed the student feedback and comments. The qualitative and quantitative analysis has been kept for the enhancement of students learning in the current and future enhancement of IVL. In the programming lab experiment interface, some basic concepts have been presented such as conditional statements, repetition structure, and array manipulation. The sample of undergraduate projects, students (response N = 100) has participated in this survey who used these concepts in last semester project activities. The 65% of students were male, and 35% were female students between 21 to 30 years old.

It was asked following questions regarding the usability, learning, and enhancement. Some of them were asked such as Q1. Have you comfortable while using the IVL? Q2. Have you understood the basic concept of an array via IVL? Q3. Have IVL guide you to verify the output results? Others were open-ended questions regarding future enhancement and any problem occurrences. The responses to few questions have summarized in **Figure 10**. In quantitative analysis, the format of questions was a Likert scale which specified the values between 1 to 5 and labels were strongly disagreeing, disagree, neutral, agree, strongly agree. The students were given slightly positive responses towards the programming concepts for usability and effectiveness. The combined frequencies have been presented as shown in **Figure 10**.

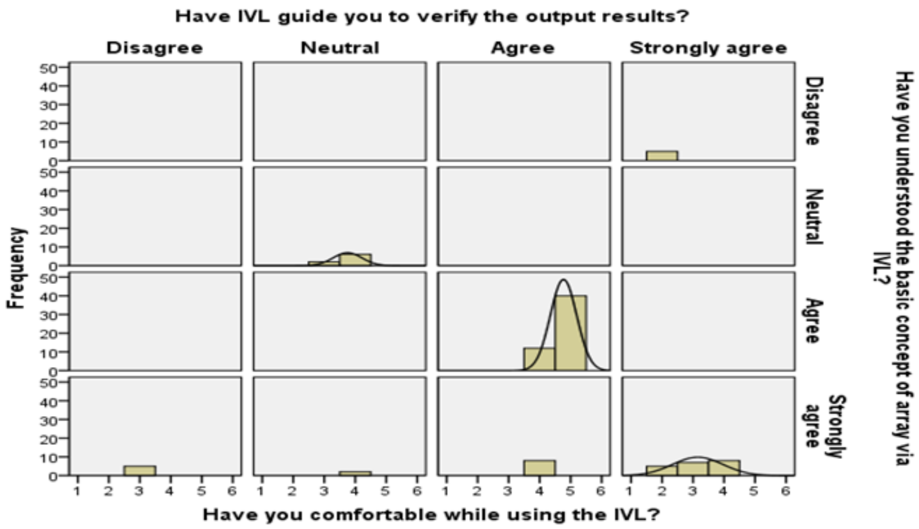

Figure 10. The frequencies on IVL questionnaire

Table 3. The mean, STD-deviation and variance on IVL questionnaire

		Have you comfortable while using the IVL?	Have you understood the basic concept of the array via IVL?	Has IVL guided you to verify the output results?
N	Valid	100	100	100
	Missing	0	0	0
Mean		4.06	4.17	4.05
Std. Deviation		.973	.779	.744
Variance		.946	.607	.553

Table 4. Chi-Square Tests on two variables of Q2 and Q3

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	150.857	9	.000
Likelihood Ratio	129.716	9	.000
Linear-by-Linear Association	.798	1	.372
N of Valid Cases	100		

Table 5. Symmetric Measures of two variables of Q2 and Q3

		Value	Asymp. Std. Error	Approx. T	Approx. Sig.
Ordinal by Ordinal	Kendall's tau-b	.310	.133	2.343	.019
	Kendall's tau-c	.240	.103	2.343	.019
	Gamma	.366	.154	2.343	.019
	Spearman Correlation	.301	.138	3.122	.002
Interval by Interval	Pearson's R	.090	.143	.892	.374
N of Valid Cases		100			

The students (N=100) have been responded, the combined mean, standard deviation, and variance have been presented in this quantitative questions in **Table 3**. The chi-square test has implemented in the survey responses and tested the hypothesis that the means of two variables have equal or significant. The Pearson's chi-squared test has analysed the comparison of goodness of fit, homogeneity, and independence types. The degrees of freedom, DF, was determined of that statistic. The chi-square test has been applied to student responses, and it has been analysed by using the IBM SPSS 19 as given in **Tables 4** and **5**. It has selected the desired level of confidence/ significance level (p-value = 0.05) for the result of the test. The results showed that the model has significant output. In qualitative analysis, it has asked open-ended questions that, are we like to hear what you think about IVL If you have any suggestions that would increase your satisfaction with the service you receive in the IVL tell us about it. Most students have provided positive responses to this question regarding expert opinions and very appreciated the solution provided for time constraint problems. It likewise made the suggestion that logical errors should be taken.

ANSWER TO RQ'S

The three research questions have been formulated in this research, the answer to these questions as follows

RQ1. How can evaluate existing services of computer laboratory work has enhanced students learning in their practical courses for examining the students' issues faced while using computer laboratory evaluation in mode wise education?

Answer: The exploratory study was evaluated through a survey that students have faced problems while performing practical tasks by using a computer in physical laboratories. The significant issues catered in many institutions are lack of instruments/updated software installation in laboratories, the insufficient time provided for practical tasks, unavailability of expert lab assistant based on subject wise, geographical and financial concerns. This survey data indicated that we could improve the laboratory practice work through automation. It offers the expertise of artificially intelligent agents which can resolve the students' problems while performing practical course tasks and they can perform tasks better at anywhere or home at any time with the full-time assistance of expert opinion agents.

RQ2. How can pedagogical cognitive architecture be constructed by proposing a unified theory of mind?

Answer: Pedagogical agent-based cognitive architecture (PACA) is constructed based on the unified theory of cognition. The PACA has divided into following three layers based on cognitive processes as shown in **Figure 6**. Cognitive modules within each layer work as information processing, which is being perceived, retrieve, restored, recall, and encoding as in a formulation of the human mind. The focus of research is to develop the CA-based agents that act and behave like a cognitive cycle in human mind simulations. It has also performed the function of different modules of the cognitive process unit. The first layer has a virtual environment which has included a web interface for graphical user interface (GUI) of the intelligent virtual laboratory, sensory memory and actuators. The second layer has included perception and action selection modules. The third layer has included cognitive agent processes such as attention, working memory, long-term memories and learning modules.

RQ3. How can be enhanced the student engagement through E-Laboratory in CLMS to be effective for practical distance learning courses?

Answer: It presents the conception of an Intelligent Virtual Laboratory (IVL) based on PACA. This IVL provides the level of excellence of laboratory needs by enhancing the education technology for all computer education levels. This IVL offers smart learning environments, which students can efficiently perform practical course tasks online at home or anywhere. The proposed research described that intelligent laboratory companion (ILC) agents based on PACA which can be used as a laboratory assistant that has the ability of self-regulating learning to assist students in practical tasks of computer skill. It discusses the allegations of findings for online laboratory needs and practice practical courses learning. The Intelligent Electronic Laboratory (IE-Laboratory) system has been designed according to the learner/student requirements of training/practical work. The task has allocated according to an eLearning student's knowledge level who aware of a virtual environment and who covered stages within time. The system has a GUI of CLMS which have apparatus and practical instrument objects for practical courses and manage sections in multiple task stages as shown in **Figure 8**. It has also shown the functionality of an example of programming concept "array" in **Figure 9**.

CONCLUSION AND FUTURE WORK

The principal aim of this work is to build an E-Laboratory infrastructure using AI and ML techniques for quality education enhancement about the learning skills and practical skills of learner/students. PACA has been developed that can serve as HCI, software solutions for eLearning and blended learning students for performing practical work. It has also facilitated those students who have an accessibility issue of practical expensive equipment in physical modes such as rural areas and time constraint for usage of these practices. Since, the proposed work can also have a distance/eLearning institution impact. It has the impact where the tangible output of the research will be displayed to the eLearning society for student engagement and knowledge sharing through E-Laboratory interfaces. The proposed research described that intelligent laboratory companion (ILC) agents based on PACA which can be used as a laboratory assistant that has the ability of self-regulating learning to assist students in practical tasks of computer skill. Furthermore, this research will enhance the experience of performing practical tasks in an online/virtual mode. It will enable students and teachers to minimize the gap between conducting experiments using tangible resources and working in a virtual environment. We are currently developing all practical courses, and the behaviour description of all system functionality using PACA based ILC that is transforming into operational architecture by using C#6 cloud web .net framework with Bootstrapping.

This development of the ILC operation model can be converted into a software prototype for conducting experiments on all courses by the integration of hardware and software modules. It can also be potentially lead to more substantial scale studies and enhance a massive project in the future.

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APPENDIX 1

https://docs.google.com/forms/d/e/1FAIpQLSd_2PAmqCXYB00-KPIGAECHeMytXuYsnVMeno7u3Rki-pkrNw/viewform?usp=sf_link

APPENDIX 2

Qualitative analysis of first 15 examples of quoted responses from students (respondents).

Q22.Which types of problems you have faced while problem solving of assigned task? (Such as program code, excel sheet calculation, MS word etc.)	Q25.Please suggest which types of parameters should be implemented in lab work? (Such as online tool available etc.)	Q27. Please identify the typesofinstruction/assistance that is needed while performing practical task in lab or at your home computer?
understanding issue complex scenario	proper guidance online lab	logic understanding
lack of knowledge	When students get class in lab, instructors should always be available for MDB or text message reply & there should be phone no of each instructor for mobile phone contact.	Yes, like Computer Networks, for this course there should be practical class so that we can learn about networking.
the use of visual studio	different code of program	the use of software
nothing	Provide complete information about the use of each new and online tools	Provide complete instructions about how to use any new tools
Errors occurred when debug the program. no output shown on display etc.	Installed applications.	Task perform curely.
program code	installed apps	lab
Problem in understanding of coding	Online tutorials	Through the video
Mostly Problem statements are not clear which Creates problems	Online tool, net facility good atmosphere	Route map to solve the problem
I have no problem in solving of assigned task.	Online tool available	First thing internet should be available.
Need of latest software's, windows, hardware requirements also quick response of queries from MDB or mail.	Windows latest release, Necessary Software's with new versions and hardware compatibility and quick response from instructors.	Help for current topic, Good internet connection, problems discussing with someone
Program code	lab software	step by step approach
Time Managing Issues	Programming Related IDE	Brain Storming Lab Tasks
Lack of facilities	High speed Internet facility	Video instructions with application
Coding was sometimes difficult due to ruthless instructions and guidance by lab instructor.	Attractive questions, online and graphical environment to present problems, visualize problem instead of written text	Practical environment complete guidance, demo, tutorial videos

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