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Use of ICT in Learning Underwater Wireless Communications: An ExperimentalStudy

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Abstract: Underwater Acoustic Wireless Communication Concepts, its layering, protocols and signal propagation remain to be vague and complex for students undergoing communication postgraduate programs. Students generally feel disinterested in learning wireless communication courses as the hectic learning content was delivered as mere lectures. The educational institutions do not consider the psychological aspects of the present generation students, as our traditional lecture-based approaches are found not suitable for this generation. The widely available scientific educational practices need to consideredand incorporated in their learning environments. These practices need to be followed both in teaching as well as in learning such complex courses. Usage of ICT, in their learning and research becomes an essential element. In this research study, a technology enabled virtual learning methodologies were created and utilized. The prime objective of this work was to create the required motivation and interest, as well as to improve their learning.

Keywords: Underwater Wireless Communication, ICT, virtual learning; e-learning; learning management.

1 Introduction

Higher Education Courses of Science, Mathematics, Engineering and Technology have a lot of proven scientific facts, concepts, principles, theorems and laws. Scientific courses cannot be taught and learnt unscientifically. The recent psychological survey (Badke-Schaub, G & Meijer M 2010) suggest that the concentration time of present generation learnersis only around 7.7 minutes as compared with earlier studies of 18 minutes (Driscoll M. P 2014). To create a learning experience in the learner's environment, usage of ICT helps in implementing the scientific educational theories thus enablinglearners to remember, understand, apply, analyze, evaluate, create and customize individuals own virtual learning environments. Learning techniques (T. Richter, S. Rudlof, B. Adjibadji, H. Bernl C. Gruninger, C.-D. Munz, A. Stock, C. Rohde, & R. Helmig 2012) and Virtual-learning environments (Y. S. Son & Y. S. Lee 2013), can be integrated along with the course instructor's inputs to form a blended learning experience for the present generation students.

In this research work, the ICT Techniques combined with various educational practices are used to conduct the course on Underwater Wireless Communication. The teaching learning course plan was designed using the popular CDIO (Karl- Frederik Berggren, Doris Brodeur, Edward F. Crawley, Ingemar Ingemarsson, William T.G. Litant, Johan Malmqvist & Soren Östlund 2003), model and Instructional System Design models (Dee H. Andrews & Ludwika Goodson 1980), Course material and active learning strategies are designed and implemented using the ADDIE (Caroline Crawford 2004), model andthe various learning theories such as; Definition Based learning (Gerald Dejong & Raymond Mooney 1986), Solution Based Learning (Norman, G R 1988), Inquiry Based Learning (Alice Y. Kolb & David A. Kolb 2012), and Experiential Learning (Julie E. Mills & David F. Treagust 2004), in addition to Project Based Learning (Savery, John R 2006), Problem Based Learning and Case Based Learning (Claus Andreas Foss Rosenstand, Jan Stage & Mikael Vetner 2008). Learning outcomes were arrived using the SMART (Lee Ann Jung 2007) principles along with the

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Revised Bloom's taxonomy of educational objectives (Anderson, L.W & Krathwohl 2001), The classroom learning sequence was designed using the Conditions of Learning (Gagne. R.M 1985) theoretical principles. The learning session also incorporated activities for learners to conceive, design, implement and to practice. Self-learning theories are also implemented using the Cone of learning (Lalley, James P, Miller & Robert H 2007), and retention of learning was ensured using Mind Maps (John W. Budd 2004). Learning Assessment & Evaluation (Kaufman.R & Keller J.M 1994) techniques were used for identifying learning progress, challenges and deficiencies. Learning feedback was obtained using the Feedback Model (Butler, Deborah L & Philip H. Winne 1995). and was incorporated for obtaining purposeful and meaningful feedback on the entire teaching and learning activities.

In this research study, the following objectives are addressed: (a) creating a mindset in learners to appreciate and understand the relevance of this course and its importance to their lives and careers. (b) Helping learners to understand the context in which this course is learnt (c) creating interest towards learning and practicing using psychological methodologies (d) utilizing theories in education with an objective to improve learning. Towards achieving efficiency and effectiveness of the set forth objectives, we utilized different ICT techniques in addition to the traditional class lectures and monitored using a well-constructed Learning Management System that was based on virtual learning environments

2 Analysis for the Study

The statistical data (Christhu Raj M R, Rajeev Sukumaran 2015) shows that the 70% of the world is covered with water in the form of oceans, lakes, rivers etc. Many researchers are working in wireless communication networks that are based on terrestrial networks and its applications. Only a few researchers in the past two decades are actually working in the world's most populated resource (water) underwater wireless communication. India is a country surrounded by water on all three sides, the Arabian Sea, the Bay of Bengal and the Indian Ocean. Research Community has understood the importance of acoustic communication and protocols for underwater wireless communication. Few elite institutions have started research labs and courses in underwater communication. However, students feel disinterested in studying this course and the academicpass-percentage results published by our affiliating university in the year 2013-2014 was less than 40 % in the wireless communication course. A survey was conducted across Institutions that offer wireless communications courses with underwater applications. The result of the survey highlights the following; a) Many abstract concepts are taught within a short duration b) Basics of wireless communication and its principles, problems are not thoroughly addressed c) Less scope for learning and practicing in actual underwater network environments d) Learners not provided with the right direction as to how to learn these courses e) No proper periodical assessments, case studies were provided etc., To sum it up, most learners had no clue as to why they are doing this course. To solve these challenges; an attempt was made. It was decided to conducta set of experiments to study in a phased manner to solve every challenge listed.

3 Design Procedure for Course

The above section highlights the underlying prime message that educational theories must be utilized while designing learning techniques. And the role of the course instructor is that of 'a guide by the side' rather than 'a sage on the stage'.

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A. Learning room environment

Psychological and Sociological theories (M. Schiro 2007) insist on the prime message that learning becomes more effective through group interaction among learners, and the role of an instructor should be that of a 'facilitator for learning'. Our learning participants have been grouped in a random fashion and frequent shuffling amongst the group members ensure that students also learn to coexist, cooperate and collaborate among one another during the learning sessions. This helped the course instructor to easily gain attention of the learners and also ensure smooth conduction of an active-cooperative learning environment. Active Learning Strategies makes students to solve problems in the lecture class itself, to interact with peer groups, and also helps in ensuring accountability for individual learning tasks.

B. Design of a Course Plan

The first and foremost step in creating a high-quality course is clearly defining its educational learning goals and objectives. This helps in selecting appropriate teaching techniques. New standards for curricula, primarily lays focus on the need for formative assessments, increasing diversity among students. The current digital world revolution has re-defined the teaching, learning and assessments in many universities. Designing a Scientific Course is like doing a good research. Large lectures were the predominant way of teaching in the past few decades, but nowadays as education reinforces on student's learning rather than the teachers lecturing abilities. It takes a certain amount of time and effort to effectively create a Scientific Course and evaluate our own teaching and students learning. Highly Scientific Courses should be designed using Scientific Strategies. Designing of any course needs to follow the Curricula Design theories (Fred Paas, Alexander Renkl & John Sweller 2003), and Instructional Design theories. These theories were implemented to create the overall course-learning plan with its respective elements such as; course objectives, course schedule, assessment, evaluation and feedback. A Visual representation using Mind Map of the entire course plan was also provided and displayed to the students to help them easily navigate through the various elements of their learning.

C. Design of Teaching-Learning Methods and Materials

Teaching and learning techniques were designed using proven educational theories (Tom Murray 1999), and standards in authoring (Alfred P. Rovai, Mervyn J. Wighting, Jason D. Baker, & Linda D 2009). The components comprise of instructional materials for teachers, worksheets for student learning, assessments, case sheets, learning evaluation tools and online feedback. By preparing effective Teaching-Learning materials and with appropriate teaching-learning methods, students would be able to conceive the concepts in the learning room.

The basic core course on Wireless Communication paved way to design courses like Optical Communication, Acoustics Communication and have brought in a lot of advancements in modern Communication Systems. To meet the prime objective of this research study of creating self-interest in our students learning, ICT enabled virtual learning support system was fully utilized in addition to instructor-led learning environment. ICT facilities were built to ensure complete interactivity among learners to enable design and test their own automation. The role of the instructor was more of a facilitator to guide the students. This constructivist learning approach motivated learners to acquire knowledge through problem-based and experiential-learning modes.

D. Learning Outcomes for Sessions

To achieve the set forth session rationale and objectives, careful planning of every session is

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done by clearly articulatingwhat the students need to conceive, design, implement and operate within the given learning period. Planning was also done to identify the cognitive, affective and psychomotor parts of the learning material. The different active learning strategies were also designed to ensure consistency in the learning process so as to satisfy their multiple intelligences (Ernie Barrington2004). Each session has a session learning outcomes and course instructor needs to decide and frame specific learning outcomes that are based on blooms cognitive levels for every session. A good learning outcome is of utmost importance to ensure that learning does happen in the class.

E. Design for Self Learning Activities

To enable both active-cooperative learning as well as self-learning capabilities, it was felt that a good supportive e-learning environment could extend their learning habits beyond their classrooms.

Hence a 24 X 7 self-based learning support environment was created with sufficient volume of multimedia content that are both stimulating and game based. Student's online learning activities are created using open source application such as Virtual Programming Lab with the Integration of Moodle. This helps the instructor in uploading various assignments and problems to be solved in online mode. The online module consists of learning materials for coding and experimenting various code snippets for learning Acoustic Communication Properties.

F. Design of Assessment & Learning Evaluation

Course Assessments (Dougiamas .M & Taylor .P 2003) enable to identify the need of learning and the impact of learning in students. Assessing learning through oral, written and demonstrations were used. Bloom's taxonomy cognitive verbs were grouped with the above assessment techniques to identify the student's participation and learning. This helped to classifying the learner`s into four quadrants of learning levels, instead of classifying them into just good and poor learners.

G. Design of a Feedback system

An online feedback system was designed using learning feedback theories (Boud, David, & Nancy Falchikov 2007), Feedback was obtained on the need analysis for learning; planning of learning strategies, design of learning methods, development of learning tools and learning self-assessment techniques. This feedback has helped in redesigning and improving the learning system by identifying the basic feedback components like a) Positive aspects of the learning b) Suggestions for the improvement c) Approaching the same topic in another perspective, etc.,

4 Development Model Phase

In this chapter the proposed model is explained. To implement the essentials, a Learning Management System (LMS) is developed using the open source framework called Moodle Torre, D. M., Simpson, D., Sebastian, J. L., & Elnicki, D. M 2005). It is divided into two essentials components namely

1. Uncontrollable Component
2. Controllable Component

5 Uncontrollable Component

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In this section, the uncontrollable elements are monitored and administered by Deans and Directors of the University, whereas the individual institutions need to follow the curriculum and syllabus prescribed. This involves various components like Designing a Curriculum and Syllabus, Learners background, Evaluation techniques and criterion, Examination results, result analysis and ranking of institutions.

A. Curriculum and Syllabus

Teaching in STEM (Science, Technology, Engineering and Mathematics) needs to have course objective and course goals. Course goals statements are broad and measured at the end of the course. Course objectives make the instructor to decide skills and knowledge that students acquire during the course of study. The Curriculum and the syllabus are based on the advice of the Dean and Directors of academics. The course instructor has no control over the syllabus prescribed. Similarly, the course instructor has no control on the learner's background and it becomes an uncontrollable entity.

B. University Examination Evaluation and Result Analysis

The university again controls the university examination pattern, evaluation techniques and the course instructor has no control on this module. Upon the publication of the results various process like result analysis, ranking of the institutions willproceed

6 Controllable Component

The Controllable component by the respective members includes; Course Learners Background analysis, Syllabus Detailing,Learners demographic background, Course learning techniques, Learning outcomes, Session learning techniques, Weekly learning techniques, Monthly learning techniques and Model Examination.

A. Course Learners Background Analysis

To incorporate the essentials mentioned in Fig. 1, a Learning Management System is implemented using open source free framework Moodle.

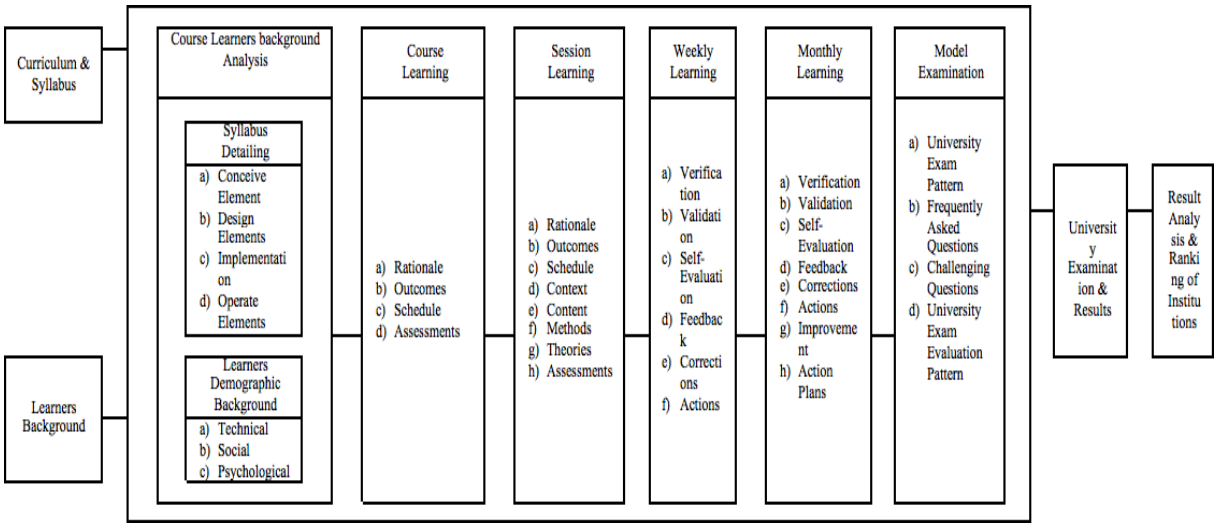

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Fig 1. Learning Management System Framework

The designed framework has features such as; course management, user management, on-line editors, file storage management, access management, and access tracking mechanisms. The first step in the proposed framework is to identify the course learner's background analysis and review their technical, social and psychological skills. Various assessments are conducted to identify the thinking styles, learning styles of the students. In this component the syllabus detailing and learners demographic background are also analyzed. While the course instructor has conducted each session based on CDIO design. Each session contents have principles, concepts, formulated laws that make the learner to Conceive, Design, Implement and Operate. With the help of psychological assessments, their thoughts and intelligences, the learner's technical, social and psychological background is thoroughly analyzed. This helps in grouping learners and shuffling them regularly.

A. Session Learning

This module consists of Session Rationale, Session Outcomes, Session Schedule, Session Context, Session Content, Methods, and Assessments.

B. Weekly Learning

Every weeks learning progression is measured using the Learning Measurement Test (LMT) conducted on a weekly basis.

This helps learners to keep track of their learning progression, and it also acts as a learning revision tool. Fig.2 shows the different learning evaluation stages to identify the student-learning progress. Based on the LMT report appropriate corrections and action plans for improving are prescribed to students. Students can provide feedback about their learning difficulties, so as to ensure appropriate corrective actions. After the conduction of the first four Learning Management Assessment Score (LMAS), the grades are calculated via equations (1) to (3),

$$LMAS_1 = \frac{\sum_{n=1}^{4} LMT_N}{8} \quad (1)$$

Where,

$LMAS$ = Learning Management Assessment Score (5 Points)

LMT = Learning Management Test (10 Points)

Similarly,

$$LMAS_2 = \frac{\sum_{n=5}^{8} LMT_N}{8} \quad (2)$$

$$LMAS_3 = \frac{\sum_{n=9}^{12} LMT_N}{8} \quad (3)$$

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A. Monthly Learning

Similar to Weekly plan, Monthly Learning model is implemented and the students will undergo Monthly Management Test (MMT). MMT Module is conducted once in a month and it is conducted for three times during the course term. Monthly Learning Module comprises of Students Learning Validation, Verification and Self Evaluation. Learning reports are generated according to the student's performance as given in Equation (4) to (6). Combining the Monthly Management Report 1, 2 and 3, a Final Consolidation report of the Student's Performance in the course term. From these reports, the learners are categorized as

1. Consistent Learning Students
2. Incremental Learning Students
3. Sedate Learning Students
4. Poor Learning Students

From these reports, the course instructor can identify and suggest remedial measures for the Average and Poor Learners.

$$MMAS_1 = LMAS_1 + \frac{MMT_1}{10} \quad (4)$$

Where,

$LMAS_1$= Learning Management Assessment Test

MMT_1 =Monthly Management Test (50 Points)

$MMAS_1$ = Monthly Management Assessment Score (10 Points)

$$MMAS_2 = LMAS_2 + \frac{MMT_2}{10} \quad (5)$$

$$MMAS_3 = LMAS_3 + \frac{MMT_3}{10} \quad (6)$$

A. Model Examination

A Model examination, very similar to the university conducted final examination is conducted toward the end of the courseto help learners to prepare effectively for the final examination. The evaluation is very much similar to that of the final examination. The Final Controllable Entity Grades are calculated using the model proposed in Equation (7). The course Instructor will have only 50 % of Grade Points and the University Examination administers remaining 50%.

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$$\text{CEAS} = \sum_{n=1}^{3} \text{MMAS}_n + \frac{\text{MUAE}}{5} \quad (7)$$

Where,

CEAS =Controllable Entity Assessment Score (50 Points)

MUAE= Model University Assessment Examination (100 Points)

7 Course Implementation

To meet the prime objective of this research study of creating self-interest in our learning students, the ICT enabled virtual learning support system was fully utilized in addition to instructor led learning environment. ICT facilities were built to ensure complete interactivity among learners, and also to enable problem based and experiential learning modes. Each concept to be learnt was designed with the following nine steps using the conditions of learning approach

A. Stimulate recall of prior knowledge

As our brain always categorizes, classifies and associates related information, recapitulation activities help learners to connect new information with existing knowledge. LMS provides opportunities for recall this through time-based active learning strategies [25] and assessments.

B. Presenting learning material

New learning content in the form of: video lectures, presentation slides, animations etc., were used for mathematical proofs and introductory information.

C. Eliciting performance of learning

Learning groups would prepare mind-maps for the concepts learnt and would also create visual tools for the assessments that were posted in their respective LMS logins [32].

D. Informing learning objectives

To satisfy both global and sequential learners, learning objectives of every learning session was perceived in LMS and learners would use inquiry modes of learning to reflect on what is known to what one needs to know

E. Gain learner attention

To bring learners existing knowledge to working memory, every learning session utilized techniques like [20]: brainstorming, quizzing, puzzling, open discussion, real-life.

F. Provide feedback of learning

Learning progress is tracked for every learner based on participation in learning activities, due mentoring, coaching, guidanceand feedbacks are also respectively updated.

G. Assess learning performance

To quantify one's learning, assessments are conducted after every learning activity, and

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results are graphically plotted to enhance their psychological perception on the progress of learning.

H. Enhance retention and transfer

In addition to supplemental learning materials introduced to enhance and retain learning, fun based puzzles, pattern-matchingexercises were provided. Poor performers were individually tracked online and grouped with better performers, and peer- learning strategies were also implemented in LMS. Learners were also asked to contribute towards enhancing the LMS thereby enhancing their retention

8 Results and Discussions

This section provides the results and discussion of our proposed model. The architecture mainly helps the instructors in finding the type of learners and their performance. Based on the Learning Management Assessment Scores a graph is shown in Fig 2 among the different types of Learners namely Consistent Learners, Incremental Learners, Sedate Learners and Poor Learners

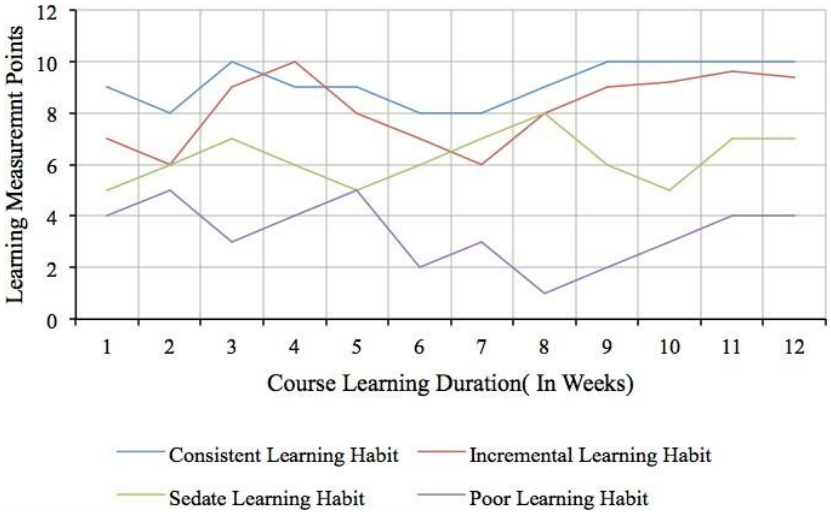

Fig 2. Different Types of Learners

From Fig 2, it becomes obvious that Consistent Learners earns more points than other category of learners. Learners are divided based on the Learning Management Assessment reports. This model helps the instructor to concentrate appropriately on Poor Learners and Sedate Learners. Graph is plotted between Learning Management Points and the duration of the course.As mentioned earlier Learning Management Report helps the course instructor to differentiate the learners and reinforces the course instructor to give more Learning Attention to the Sedate Learning Habit Students and Poor Learning Habit Students. Fig 2 shows that Consistent Learning Habits Students and Incremental Learning Habit Students excelled in the Learning Management Report Points. Sedate Learning Habit students and Poor Learning habits student's has maintained to increase their grade points towards the end of the course term. The implemented model helps the students to learn and review their reports and points every week. The course instructor can accordingly take appropriate remedial measures to make students work for their learning management points. Fig 3 shows the final count in the different quadrant of the learners. According tothe Final Monthly Management Report, the

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learners were fit in to appropriate quadrants. Certainly learning and grade points were improved when compared with the last term course for the same subject. The use of various effective educational learning theories mentioned earlier has certainly helped the in this case.

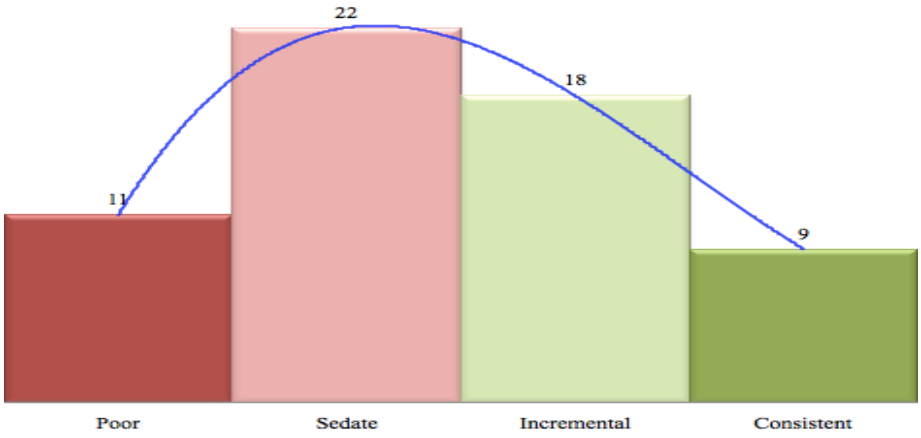
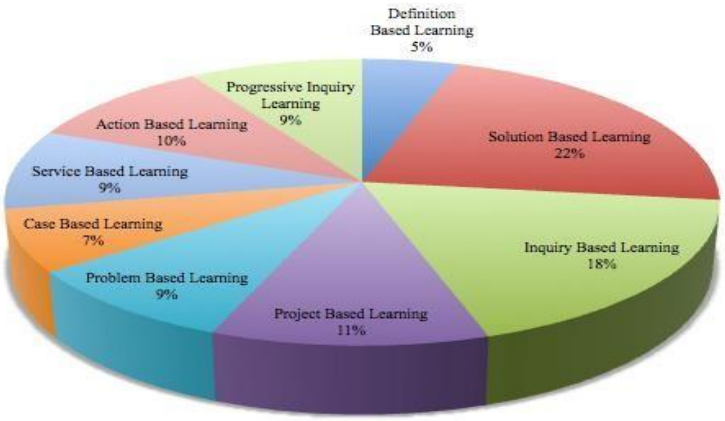


Fig 3. Quadrant of the Types of Learners

Fig 4 shows the various active and cooperative learning techniques used by the course instructor during the course term of wireless communication. As mentioned earlier, the Bologna process as completely redefined the term teaching as learning and teaching curriculum is replaced with learning curriculum. The prime goal of the educational theories proposed to engage students and learning happens in the class. Solution based learning, Inquiry Based Learning, project based leaning and problem-based learning were given prior importance than other active cooperative learning techniques. Fig 5 shows the Course Instructor's working load for completing each module in the course term. As in the previous course delivery model, each module takes an equal amount of time for completing the course.

Our proposed model enables the course instructor to complete the delivery process with in 40-42 hours



compared to 50-55 hours in the previous model.

Fig 4. Active Cooperative Learning Techniques

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Initially it takes time to complete the first module in the course. Students took time to adopt the new learning techniques and new learning strategies. Once they adapted to it new system, the course delivery process becomes easy for the course instructor. This is because students were engaged in different active and cooperative techniques.

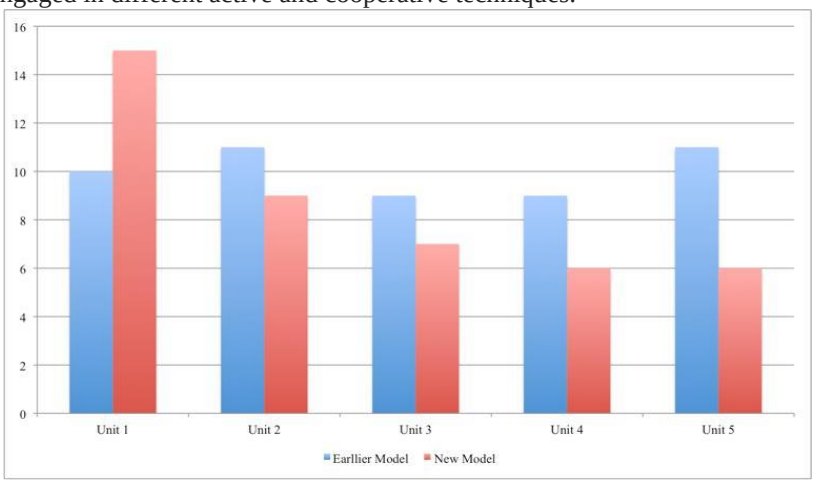

Fig 5. Course Instructor Work Load for Completion of Modules

Table 1 Comparison of Previous and Proposed Model

Parameter	Previous Model	Proposed Model
Course Delivery	50-55 (Hours Average)	40-45 (Hours Average)
Grade Points	34 (Average) /50	41(Average)/ 50
Pass Percentage	64.21 %	81.41 %
Innovative projects	1	7
Feedback Participants	38 %	96 %

Table 1 shows the various parameters used comparing the existing model and the proposed model.

9 Conclusion and Future Enhancements

This research study on the use of ICT for the course Wireless Communication helps any teaching researcher to introspect the present modalities followed, and adapt new and better practices in producing meaningful and purposeful learning in our present generation students. Student feedback about the entire course has been highly positive; most students expressed that they would like all their courses to be converted into such ICT supported courses. It would be highly appropriate to conduct short action research activities on fundamental courses of engineering like mathematics to proactively prevent the highest number of failures recorded year after year across the country. The LMS, Wireless Communication course materials, evaluation reports are available in the course home page as well as in the repositories.

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