Lecture # 01

Topic: Introduction

In this course we will identify

- the problems of learning
- how to address those problems of learning through pedagogy and technology
- what is pedagogy
- what is technology
- how to design pedagogical and technological content

We assume that you know about pedagogy and basic information technology already. Now we will study their use in order to address problems of learning in a classroom. Classrooms settings discussed in this course can be of high school, middle school or a university classroom. The more concentration in this regard will be on mathematics and science subjects. Arts and humanities can also be a part because problems are almost the same and ideas can be applied to other subjects as well.

Example:

When a teacher enters a classroom, his aim is to teach the students. For example, if a mathematics teacher enters a classroom he may want to teach functions & relations or discrete mathematics. If he is a teacher of calculus he may want to teach differentiation and integration. If he is a physics teacher, he may want to teach Newton’s laws. So the question is what is his purpose to teach the laws? Are his students able to solve any practical problem in life by using these laws?

It is not enough that a student is able to answer the questions given at the end of the lesson about Newton laws. In fact, a teacher must be more ambitious and must watch a change in students’ thinking. Students must try to understand the concept of Newton’s laws and also try to solve problems by applying these laws.

This course is not about teaching you the content of Newton’s laws, periodic table or calculus but instead letting you discover the problems that a teacher may face while teaching these and other such topics. Firstly, these problems should be highlighted. We must have such tools and techniques according to which we can identify the difficult topics to teach and understand. Where and what is the difficulty in these topics? There are some topics which are easy to teach to the students and some are difficult. So, why these topics are difficult to teach? When we say that a student has learnt something, his parts of brain are working continuously. At first part, there is only rote learning. Second is about understanding and at third level the brain’s logic level starts working. At this level, a child can generate meanings through the concept. A student can think more than the topic itself. Full reasoning ability of the mind is active and all sub-systems of the

brain are working at the same time. A teacher can reflect on his teaching at the end of the lecture to investigate the level of understanding of the students.

Here the problems that are highlighted are actually the complexities in the topics which are difficult for the teacher to communicate properly and for the students to understand.

Introduction

The problem of integrating technology into the teaching and learning process has become a perennial one. Common excuses for the limited use of technology to support instruction include shortage of computers, lack of computer skill and computer intimidation. While these could affect the success of technology integration, it should be acknowledged that the degree of success teachers have in using technology for instruction could depend in part on their ability to explore the relationship between pedagogy and technology.

Using technology to enhance the educational process involves more than just learning how to use specific pieces of hardware and software. It requires an understanding of pedagogical principles that are specific to the use of technology in an instructional setting. Pedagogy-based training begins by helping teachers understand the role of learning theory in the design and function of class activities and in the selection and use of instructional technologies. (pp. 2 and 6)

The relationship between instructional technology and pedagogical concepts is considered with a view of assisting teachers to recognize the impact of such a relationship in an educational inquiry. Technology integration is complex and is made up of processes of interconnected activities.

Why a topic is easy for the students and why it is difficult?

It's hard to get students to learn basic anything unless they are motivated to learn. Not all students will be motivated to learn any given subject. When it comes to something that can be somewhat complicated and mathematical (even at relatively basic levels) it becomes harder still to get students to learn.

For example, physics topics: Some students may feel that physics isn't important to them. They may not find it interesting or useful. Of course, one day they will discover that physics is everywhere. If you are having trouble keeping your students' attention, try relating physics to something they are interested in.

Prior knowledge of the students

Prior knowledge is important because it helps a person make sense of the world. This also helps to determine how much readers will comprehend and how well a writer will be able to communicate about a certain topic. Although it is true that the extent to which students will learn this new content is dependent on factors such as the skill of the teacher, the interest of the student, and the complexity of the content, the research literature supports one compelling fact:

what students *already know* about the content is one of the strongest indicators of how well they will learn new information relative to the content.

A teacher must plan properly before teaching any topic. What is the teaching method that is more appropriate for the students to learn? When a teacher assumes that a student must start thinking something about the topic on the basis of his/her prior knowledge and teacher thinks about the method to teach is actually called as **pedagogy.**

Pedagogy

The method and practice of teaching, especially as an academic subject or theoretical concept.

Pedagogical tools

A pedagogical tool is anything that a person uses to learn or teach. Some pedagogical tools such as textbooks are considered "traditional," but as the needs of students and teachers change, less-traditional items are becoming pedagogical aids. Exactly what a person considers a pedagogical tool varies by age and education level, but virtually anything can be a pedagogical tool in the right circumstances. It is normal for the amount of training required to use different tools to vary.

Traditionally, pedagogical tools include items such as worksheets, textbooks, handouts and hands-on models. As people have learned more about the way individuals learn, however, educators and students have branched out to other types of pedagogical tools.

For instance, a person might consider something as large as a pedagogical tool if a teacher could use the structure to demonstrate architectural principles of physics, material selection in building, math and similar topics. Although traditional pedagogical tools are found in just about every subject area, some tools are used with greater frequency or make more sense in particular fields, such as a microscope in biology or medicine.

Pedagogy also includes assessment, context (what is the purpose for teaching the content), prior knowledge, classroom environment, curriculum, (All these things inform us about pedagogy)

Technology

Technology has played a major role in instruction now a days; with students and teachers using tools such as websites or mobile device applications.

Teaching in class:

A teacher must know the technology and its use in classroom. He must pre plan for the problems that he thinks he could face during teaching and their solutions as well.

Pedagogy is a learning process that is endless. There are different tools and techniques of pedagogy. Knowledge continues to reshape itself so a single pedagogical tool or skill is not

enough in all the situations. Therefore, a teacher must try to analyze the effectiveness of the tools used as well.

History of teaching

The learned men of ancient times, by default became the teachers. Priests and prophets taught children of the wealthy and noble, the skills to take up their roles as leaders and businessmen. The priests' position was elevated above many strata of society, and they were treated accordingly for their knowledge and wisdom. Teacher appreciation was a widespread feeling, and respect for teachers was proportional to their high value in those societies.

In past, there was programmed instruction, which was applied to the student according to his immediate feedback in the class. Learning outcomes were constant.

The quality of the class will depend solely on the quality of the teacher and not the presence of technology.

Comparison of Traditional and Modern Classroom.

Old classroom	**Modern classroom**
Single room school	Many classes in a school
Single instructor	Single instructor for a class
Limited content	Same content for whole class
People from different age groups	People of same age groups
Teaches many subjects at a time	Teaches one subject at a time in class
Immediate feedback	No immediate feedback
More discussion method followed	Lecturing
Teaching was on the basis of prior knowledge	Prior knowledge is not tested. Some students get the topic clearly while others do not
Teaching according to students' interest	Teaching according to students needs
Focus on students' understanding	Focus is on covering the syllabus
No admission tests were administered	Admission after clearing a test
Limited technology	Content, pedagogy and technology are used according to students level of learning

What about future classroom Our modern classroom must consist of the values and methods of the ancient classroom using technology and pedagogy, it will be our future classroom.

Informal to formal classroom

During the primitive times, all education was informal. It was limited to activities like hunting, fishing, work shopping, and protection from the natural calamities, and so on. The child could learn such life activities by direct participation in day-to-day life of the community. At that time, life was very simple. So was the social order and culture. With the growth of civilization and advancement in the field of science and technology, the accumulated knowledge and the skills became more and more complex, which created the need for formal education.

Addressing problems of learning through pedagogy and technology:

Technology in education is commonly defined as a technical device or tool used to enhance instruction. Educational technology might include media, models, projected and non-projected visual, as well as audio, video and digital media. This definition does not take into consideration the pedagogical principles upon which the application of various technologies into educational inquiry is based. Such a definition is narrow because it isolates technology from pedagogical processes that it is intended to support. It does not connect instructional technology with the learning objectives, methods of instruction, learning style and pace of learning, assessment and evaluation strategies, including follow-up procedures. Specifically, technology integration should incorporate the technological skill and ability to use pedagogical knowledge as a base for integrating technology into teaching and learning. This implies that teachers should develop strategies to motivate students to keep them focused as the instruction progresses and to consider that different students prefer different learning styles and that they learn at different rates.

It is important that teachers use a variety of teaching methods, and students must be taught to use the newly acquired knowledge and skill as well as to critically evaluate and modify such knowledge. In other words, teachers should be able to engage students in an exploratory learning experience which is designed to stimulate thinking. To instruct someone ... is not a matter of getting him to commit results to mind. Rather, it is to teach him to participate in the process that makes possible the establishment of knowledge.

In a broad sense, technology integration can be described as a process of using existing tools, equipment and materials, including the use of electronic media, for the purpose of enhancing learning. It involves managing and coordinating available instructional aids and resources in order to facilitate learning. It also involves the selection of suitable technology based on the learning needs of students as well as the ability of teachers to adapt such technology to fit specific learning activities. It calls for teachers’ ability to select suitable technology while planning instruction. It also requires teachers to use appropriate technology to present and evaluate instruction as well as use relevant technology for follow-up learning activities. Such a broad definition of technology in education will help teachers develop a rational approach toward technology integration.

Lecture # 2

Topic: The benefits, uses and importance of the course in teaching and learning?

Effective teaching using pedagogy and technology:

Teacher education has historically focused on content knowledge. It was assumed that by knowing the content area (e.g., science, math, social studies), teachers would be able to successfully teach their students. More recently, however, practitioners and researchers have come to recognize the need for teachers to command varied and different forms of knowledge. Knowing the content, what and the why, is not enough for teachers to be able to teach effectively. Teachers must also possess pedagogical knowledge (i.e. know how to teach). In other words, effective teachers utilize both content knowledge and pedagogical knowledge, and understand and appreciate how the two are interrelated.

Researchers have recently questioned and explored how teachers’ technological knowledge fits into effective teaching practices. Technological knowledge by itself is not sufficient for teachers if they want to teach effectively using technology. The intersection between technological, pedagogical, and content knowledge provides guide for effective teaching.

Responsibility of a teacher:

Teacher is responsible for creating a classroom environment geared towards learning and discovery where students are excited and curious. It is his/her responsibility to find the right pedagogy and technology to aid him/her to achieve the desired learning outcome.

Learning outcomes can be measured to assure the amount of learning that takes place. These can be measured through examination or tests.

What are learning outcomes?

Learning outcomes are statements of a learning achievement and are expressed in terms of what the learner is expected to know, understand and be able to do on completion of the module. They may also include attitudes, behaviors, values and ethics.

Learning outcomes are an important tool. Measuring whether or not learning goals have been achieved at the end of a course helps identify gaps in learning and focus on areas for improvement.

The benefits of technology to teaching and learning:

With the increasing presence of technology in our classrooms, and the comfort of students using technology, it is important for faculty to understand the pedagogical implications of integrating technology into their classrooms. It is important to provide a model classroom for faculty to see best practices exemplified, and observe how the various technologies can be integrated in

teaching and learning. Instructional or educational technology should be “integral to teaching practice” and not viewed as an add-on to teaching.

The benefits of pedagogy to teaching:

Pedagogical content knowledge is a type of knowledge that is unique to teachers, and is based on the manner in which teachers relate their pedagogical knowledge (what they know about teaching) to their subject matter knowledge (what they know about what they teach). It is the integration or the synthesis of teachers' pedagogical knowledge and their subject matter knowledge that comprises pedagogical content knowledge.

What a teacher must do to integrate pedagogy and technology:

Pedagogical content knowledge is the teaching strategies that are used to deliver content and teachers know much more about it. Many teachers don't think about this knowledge as important. It is important, though, because it determines what a teacher does from minute to minute in the classroom, and it also influences their long term planning.

Teachers can try new ways to explore if the students understand the concepts being taught. Some strategies that the teacher can use are:

1. Ask students about how and what they understand (not in the sense of a test, but in the sense of an interview).
2. Ask students what "real life" personal situations they think the topic relates to.
3. Try to get inside students’ head and see the ideas being taught from their point of view.

Teachers need to hold discussions with other teachers about teaching. Take the time to find someone you can share ideas with and take the time to learn to trust each other. Exchange strategies for teaching difficult concepts or dealing with specific types of students to develop a learning community.

Lecture # 3

Topic: How will we use and achieve benefits of pedagogy in teaching and learning?

Quotation:

“I keep six honest serving men; they taught me all I knew. Their names are what, why, when, how, where and who.”

Rudyard Kipling

Rudyard Kipling (1865-1936) was born in Bombay, but educated in England at the United Services College, Westward Ho, and Biddeford. In 1882 he returned to India, where he worked for Anglo-Indian newspapers. His literary career began with *Departmental Ditties* (1886), but subsequently he became chiefly known as a writer of short stories.

In addition to the above quotation:

Any body of knowledge can be created on the basis of these men; what, when, why, how, where and who. Moreover, you should have an open mind when you want to learn something instead of having pre-determined answers to a question. The word ‘serving men’ is used because it seems as ‘what, when, why, how where and who’ are important tools to seek solution to a problem.

Review of the previous lesson:

Creating an effective learning environment in a classroom that enables and facilitates learning is the prime responsibility of a teacher.

Now what are the problems of learning and teaching and why do these problems exist?

Firstly, a concept may be easy to teach to the students and more or less they understand it however, deploying that concept to solve a problem is sometimes challenging and thus students find it difficult.

In other words, at times the concept itself is not difficult but it is difficult to integrate it with the rest of the knowledge and activities. Knowledge is only useful when we know how to apply it in real world settings.

It is expected from a teacher to know why such problems exist in a class so that they are able to solve the problems. The teacher should know where the problem in teaching and learning is and how to tackle it. He should have different options and ideas to do so.

Finding solutions to problems of learning is a process in itself. It is important that a teacher has grasp over the content as well as the theories of learning. An effective technique is to break down bigger problems into smaller chunks, identify where the problem lies and then address the chunks.

Learning theories play a vital role in identifying and solving the problems of learning.

What is a Learning Theory?

A theory is an explanation for why something occurs or how it occurs. Typically theory is generated by a question or by our curiosity, and offers a response to that question. A theory of learning aims to help us to understand how people learn. Many theories of learning were generated in the 20th century.

- **Behaviorism:**

Behaviorism assumes that a learner is essentially passive, responding to environmental stimuli. It believes that a learner starts out with a clean slate, and behavior is shaped by positive and negative reinforcement. Reinforcement, positive or negative, increases the possibility of an event happening again. Punishment, both positive and negative, decreases the possibility of an event happening again. Positive reinforcement is the application of a stimulus. Negative reinforcement is the withdrawal of a stimulus. Behaviorism is a precursor to cognitive learning.

Example:

Learning through positive reinforcement is an example of a behaviorist technique. Positive reinforcement typically involves a parent and a child. When a
child does something well, the parent decides to give the child a reward. After enough rewards, the child learns that a reward system is set up when something is done well. Therefore, the child learns how to respond to that particular situation.
Negative reinforcement is also a technique that supports behaviorism. When a child does something wrong and is punished, the child realizes, after enough punishment scenarios, that there is something wrong in the act committed and therefore stops performing the action.

- **Cognitivism:**

The cognitivist goes inside the learner’s head to see what mental processes were activated and changed during learning. Knowledge is viewed as symbolic mental constructs; learning involves how those constructs are committed to memory. Behavior may change, but only as an indication to what is going on in the learner's head.

Example:

Constructivist approaches can also be used in online learning. For example, tools such as discussion forums, wikis and blogs can enable learners to actively construct knowledge. Because existing knowledge schemata are explicitly acknowledged as a starting point for new learning, constructivist approaches tend to validate individual and cultural differences and diversity.

- **Constructivism:**

Constructivism is a philosophy of learning founded on the premise that, by reflecting on our experiences, we construct our own understanding of the world we live in. It is "based on a type of learning in which the learner forms, or constructs, much of what she learns or comprehends."

The constructivist view of learning:

- Learning is an active process
- Knowledge is constructed, rather than innate, or passively absorbed
- Knowledge is invented not discovered
- All knowledge is personal and idiosyncratic; all knowledge is socially constructed
- Learning is essentially a process of making sense of the world
- Effective learning requires meaningful, open-ended, challenging problems for the learner to solve.

Theories of learning can give us answer to the questions like what is:

- Understanding
- Meaningful learning
- Rote learning vs. meaningful learning
- Tools and techniques to measure meaningful learning

Meaningful learning:

Contradiction-> Resolution -> Understanding

A teacher must have mastery on the content knowledge, pedagogy and learning theories. Technically, it is known as **Technological Pedagogical Content Knowledge (TPACK).**

Technological Pedagogical Content Knowledge (TPACK) is a framework to understand and describe the kinds of knowledge needed by a teacher for effective pedagogical practice in a technology enhanced learning environment.

To teach the students through pedagogy, a teacher must plan a class by keeping in view:

- The content present in the book
- Pedagogical theories
- Prior knowledge of students
- How the students would be linking the new knowledge with their prior knowledge
- Which new concepts will be introduced while teaching the topic.
- The linkage between the old and new concepts
- The soundness of the structure of knowledge

When a teacher plans according to the points given above, he is following a constructivist approach.

Constructivist Approach:

Constructivism is an educational philosophy which holds that learners ultimately construct their own knowledge based on their prior knowledge and experience, so that each person's knowledge is as unique as they are.

Given that the required building blocks of knowledge already exist, the challenge is to identify the relevant ones and rearrange and manipulate them to create new higher level building blocks.

Contextual knowledge:

Contextual knowledge is the application of knowledge in real life context. For example,

After presenting the kinetic energy equation in class, have the students pair off for just a few minutes and practice using it so that they feel comfortable with it before being assessed.

Lecture # 04

Topic: Application of Pedagogical tools and techniques to design pedagogical content.

In this lecture, the students will be able to learn how to apply the tools and techniques of pedagogy in order to design pedagogical content for a topic.

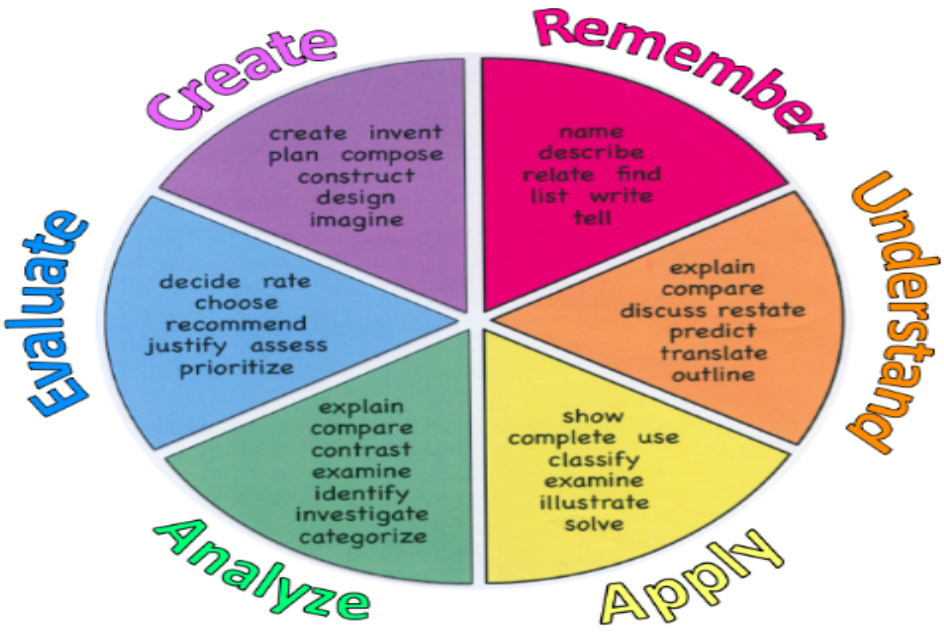
Review of the previous lessons:

The students have learnt the following till now

- What is rote learning
- What is meaningful learning
- How learning takes place
- Why sometimes it doesn't take place
- How can we identify problems and facilitate learning

From rote learning to meaningful learning, there are many stages like stages of Bloom's taxonomy. It includes rote memorization, understanding of the concept, applying it in real world settings, criticizing and evaluating it, critical thinking and discovery etc.

Read more about Bloom's taxonomy (Suggested).



Let's start by a quotation from a research paper:

"A major goal of this research was to understand the relationships between two key domains: teacher thought processes; and teachers' actions and their observable effects on learners." Mishra and Koehler

(Study the complete paper uploaded on LMS in the Lesson Content Manager Tab titled "Introducing Technological Pedagogical Content Knowledge.")

More on the above quotation:

The more flexible the thought processes of teachers, more differently he can think about the content of the topic. He can impart knowledge to students flexibly. He must also be able to know the effects of these processes on the learner. Teaching is a complex system.

Differentiation between content knowledge and pedagogical content knowledge:

Content knowledge is knowing your subject matter. For example, if you teach English or Language Arts, you have read and are familiar with the literature.

Pedagogy is the art of teaching/education. Pedagogical knowledge is knowing how to impart that information to your students in the most effective method.

It has been noticed that lots of new teachers have plenty of content knowledge. It's the pedagogy that's the hard part. Most pedagogy is learned through experience.

By combining both content and pedagogical knowledge, it becomes **pedagogical content knowledge.** Design of pedagogical content depends on the objective of teaching that content.

For example:

Content Knowledge	Pedagogical Content Knowledge
Memorizing newton's laws, definition and representation of differentiation and integration	Teaching in a way so that students meaningfully learn these concepts

This is a design course in which the content of the subject is available and students have to decide on the pedagogical knowledge of it. What could be the possible pedagogical designs?

Pedagogical strategies:

1. **Intuition**
2. **Abstraction**
3. **Problem solving**

While designing pedagogical content knowledge, a teacher should know the different learning styles. i.e.

- Visual
- Auditory
- Kinesthetic

(Read more about learning styles…. suggested)

Pedagogy is a design, and designing something requires inputs and some outputs.

Inputs	**Outputs**
- Pedagogical knowledge - Content knowledge - Bare, minimum technology	- Pedagogical content knowledge

While designing a pedagogical content knowledge, firstly, a teacher must know the prior misconceptions of the students about the concept that can be a hurdle in future learning. Secondly, complicated problems must be broken down into simple rules and procedures. Your prime responsibility as a teacher is to identify and address the misconceptions in the minds of your students regarding a topic or concept.

It is important to link the prior knowledge of students with the new knowledge being presented to them. One problem is that we jump directly to the abstract concepts from concrete ones. Abstraction is a complex state of understanding. A teacher must take the students from known to unknown, simpler to complex. Support their learning with different aids.

Lecture # 5

Topic: Pedagogical Content Design in Kinematics.

Quaid – e- Azam was once quoted saying,

“Education is a matter of life and death in Pakistan. The world is progressing so rapidly that without a requisite advance in education not only shall we be left behind others but may be wiped out altogether”. Sept 26, 1947.

Recap of the previous lesson:

- What is content knowledge
- What is pedagogical knowledge
- How to design pedagogical content knowledge
- Different pedagogical techniques

Quotation:

“If I can see further than anyone else, it is because I am standing on the shoulders of giants” Newton.

Newton said a very important thing that if something falls over his head or falls near him like an apple, then how he guesses from it the way moon, stars or sun move. Its reason is probably that he had the knowledge which was generated by the people before him. So, Newton is basically talking about prior knowledge. If we provide prior knowledge to somebody or try to build new knowledge on that then new things can be discovered easily and new things can be understood easily. Basically, Newton here wants to highlight the point that always assess the relevant prior knowledge of your students before presenting any new knowledge to them.

In addition to judging the prior knowledge of students, a teacher must know the instructional design to teach a concept.

- How to impart certain knowledge to students?
- What is the students’ psychology of learning
- Theories of learning

“The first topic most authors cover in their introductory Physics book is Kinematics. They make this choice because students must have a firm grasp of position, velocity and acceleration before they can study the topics in Newtonian Mechanics. Unfortunately kinematics encourage students to go for formula hunt and plug.” William Moab

Kinematics: “The branch of mechanics concerned with the motion of objects without reference to the forces that cause the motion.” It involves the concepts of velocity, displacement and acceleration.

While learning to solve kinematics, students usually have far too many equations bouncing around inside their heads. Their problem solution includes equations like expression of final velocity, the range formula, the maximum height formula… But physics is not a study of equations; it is a study of fundamental principles. Most of which can be expressed as equations. Even when teaching kinematics, I tell the students that they will never understand physics if they approach it as a bunch of equations to memorize. I have to emphasize that they have to learn to think in terms of principles; unfortunately that message is difficult to get across when students see equations after equations in their text books. It is especially difficult because in high school most students have learnt the old fashioned problem solving technique to identify the known then plug these into the right equations to find the unknowns.

Let us take a look at the objectives stated in F.Sc. Book of Physics and that of O – Levels for the chapter on Kinematics and compare the two.

Learning Objectives (F.Sc. Book)

1. Understand displacement from its definition and illustration.
2. Understand velocity, average velocity and instantaneous velocity.
3. Understand acceleration, average and instantaneous velocity.
4. Understand the significance of area under velocity time graph
5. Recall and use of equations which represent all these quantities

In the book of O levels, learning objectives are:

1. Interpret given examples of non-uniform acceleration
2. Plot and interpret distance time graph and speed time graph

See how they have talked about plotting and interpreting both side by side which was totally missing in our book of Punjab Textbook Board. In the later book, there is neither any stress on interpretation nor do they mention the story behind the concept. The other objectives in the O-Levels book are:

3. Interpret examples of non-uniform acceleration
4. Plot and interpret a distance time graph and speed time graph
5. Deduce from the shape of distance time graph when a body is

i. at rest

ii. moving with uniform speed

iii. moving with non-uniform speed

6. Deduce acceleration from the shape of speed time graph

Moreover, within 7 years, the following revisions have been made in the O-Levels Physics books which are in line with the Harvard Calculus Rules.

The major differences in FSc and O level books are given below:

Learning objectives of FSc book	**Learning objectives of O levels book**
Rote learning	Understanding
No focus on interpretations	Focus on interpretations
Graphs only for learning	Plotting and interpreting of graphs
Recalling of equations	Understanding and applying the equations

Comparison of old edition and new edition of O levels physics book:

Old Edition of O Levels Physics Book (year 2000)	**New Edition of O Levels Physics Book (year 2007)**
23 diagrams	More than 50 diagrams and graphs
Concepts of acceleration,	Concepts of acceleration,
Displacement and velocity covered in 17 pages	Displacement and velocity covered in 26 pages

The O-Levels Kinametics chapter starts off with the following example:

Sky diving is an adrenalin filled extreme sport which has its own dangers. In 1987 Gregory Robertson did the most daring rescue in his lifetime. He saw a fellow sky diver Debbie Williams falling past him unconscious. He increased his speed to go after him in midair. He caught up with him when he was only a few seconds from the ground before the parachute was released. So, how did he manage to alter his speed while free falling? You will find out soon.

They claim that after reading these 26 pages of the chapter the student will understand how he tried to rescue his colleague. They have started from instantaneous and average speed. They did not start with a velocity because when we start with velocity, vector addition has to be mentioned, though it can also be avoided. So, when starting from speed, direction is eliminated.

They have made a graph of speed and below that, a graph of time has been made. So, Harward Calculus rule was that we should try to explain a concept both graphically and analytically. However, if you see the F.Sc. Physics book carefully, you will hardly find any such diagram. You will not be able to find any diagram about displacement and velocity, about displacement drawn with time, then velocity, then acceleration. You will see any diagram drawn on scale. So,

the graphical aspect is completely missing. Nonetheless, in the book of O Levels, they have shown things analytically and graphically, though not numerically. Furthermore, concept maps are also included in O level books.

Concept maps can be used to:

- Check the missing links in the minds of the learners about a concept
- Design questions to assess a link
- Identify gaps in knowledge

Lecture # 6

Topic: Discovery Based Learning

In this lecture, the students will be able to learn:

- What is Discovery based learning
- How Discovery based learning can be used
- What are its pros and cons

History:

Discovery based learning (DBL) was invented in order to:

- Make use of knowledge.
- Integrate it with new knowledge.

Discovery based learning has a direct link with the theory of “**Constructivism**”

Constructivism is a theory of knowledge that argues that humans generate knowledge and meaningfrom an interaction between their experiences and their ideas. The theory suggests that humans construct knowledge and meaning from their experiences.The constructivist approach emphasizes the use of pre-existing knowledge as building blocks to achieve new higher states of knowledge via exploration, discovery and problem solving.Discovery based learning is a method to achieve constructivist learning.

Example:

Some activities encouraged in constructivist classrooms are:

- Experimentation: students individually perform an experiment and then come together as a class to discuss the results.
- Research projects: students research a topic and can present their findings to the class.
- Field trips. This allows students to put the concepts and ideas discussed in class in a real-world context. Field trips would often be followed by class discussions.
- Films. These provide visual context and thus bring another sense into the learning experience.
- Class discussions. This technique is used in all of the methods described above. It is one of the most important distinctions of constructivist teaching methods.

Psychologists related to DBL:

1. **Jean Piaget:** He had the approach of discovery and constructivist.
2. **Jerome Bruner:** He was interested in child psychology. His approach is also constructivist and a discovery based approach.
3. **Grauer School:** They developed a school curriculum from beginning to high school, which is all based on discovery based learning.
4. **Kim Novac:** He also focused on constructivism and discovery based approach. Novac pointed out that pre-school children intuitively gain knowledge by experimenting with things and solving problems.

(Suggestion: Learn more about constructivism and Grauer School from internet)

Teacher should connect everyday problems with the curriculum so that students are motivated and interested to solve them. Make the process of learning as natural as possible.

Discovery Based Learning:

- is child centered;
- allows student autonomy and independence;
- allows tailor made problems for a particular group of students;
- enables students to put in use a certain concept or knowledge.

Challenges of DBL:

- Work intensive
- Teacher intensive
- Requires lot of motivation
- Time management is difficult
- Curriculum delivery is a challenge
- Over specificity of concepts
- Doubt of remaining misconceptions
- Workload increases for both teacher and student

With reference to a book, "Learning and Teaching in Higher Education, The Reflective Professional" by Greg. Light. Dox and Susanna Calkins.

Three categories are highlighted, which are also related to the challenges of DBL.

Categories of Conceptions of Teaching:

- **Conventional Lecture Method:**
- Knowledge is transmitted,
- teacher focused,
- student learning is not a headache of teachers.
- **Acquisition of knowledge:**
- Student focused,
- Learning of concepts by students is the focus;
- Here the teachers want the students to learn and understand, he can do this through examples and explanations or demonstrations;
- Question answer session is held at the end.
- **Engagement method:**
- In this book, DBL is called engagement method.
- Learning focused
- Student learning as conceptual development and understanding is the teacher's concern.
- A teacher must work in developing ways to improve and change their conceptual understanding.
- Students play an active role in the classroom.

Now, there is always a difference in teaching a method and stating a conclusion. If students are taught through a method, they will retain it for a long time. But if you state only a conclusion, students will forget it soon.

The main differences are:

Teaching a Method	Stating a Conclusion
- Useful	- Trivial
- More likely to be remembered	- Likely to be forgotten

Intuition: It is a method/way of thinking that does not need to be taught to students. If you keep practicing a certain method of thinking, it becomes part of your intuition. In other words, it becomes automatic for you. Discovery based learning is build on intuition.

Keep the learning process open. Let children make mistakes and allow them to learn through it. Intuition is at the heart of problem solving engine, knowledge creation and discovery. A teacher should come down to the level of students and imagine what their intuitions, prior knowledge and assumptions are.

Socratic Method:

Same was the thinking of Socrates. Socrates valued the knowledge and understanding in people and thought that using this knowledge can be potentially be beneficial in advancing their understanding. Intuition is the pre-existing process or method of thinking.

By helping students examine their premonitions and beliefs while at the same time accepting the limitations of human thought, Socrates believed students could improve their reasoning skills and ultimately move toward more rational thinking and ideas more easily supported with logic.

Short comings of Socratic Method

The short comings of Socratic Method are more likely same to those of DBL because it is the sub-type of it.

- Teacher intensive
- Effort intensive
- Rate at which new concepts can be introduced is out of control of teacher

Moore Method:

The Moore method is a deductive manner of instruction used in advanced mathematics courses. It is a very challenging method.

In Moore's Method

- Students are presented with problems and they have to solve them creatively
- Students learn and understand through succession of failed attempts
- It is through the succession of failures that things are worked out and insights are gained.

G. Polya was not a psychologist, nor did he have any pedagogical knowledge or training, as he writes in his book "How to solve it."

A great discovery solves a great problem but there is a grain of discovery in the solution of any problem. Your problem may be modest but if it challenges your curiosity and brings into play your inventive faculties and if you solve it by your own means, you may experience the tension and enjoy the triumph of discovery. Such an experience at an early age can be very beneficial.

A teacher must decide how much time and attention should be given to procedural knowledge and on discovery based learning. A teacher of mathematics has a great opportunity if he fills his time in drilling his students with routine operations. He kills their interest, but if he challenges

the curiosity of his students by setting them problems appropriate to their knowledge and helps them to solve their problems with stimulating questions, then the real purpose of learning is achieved.

This approach is different from Moore's method. Moore's approach was very hard and challenging. Moore is not in the favor of guiding the students to solve a problem but Polya did this by facilitating the students:

- A teacher should make a teaching management plan.
- Facilitate the discovery learning process of students by asking questions that promote their mental operations.
- Ask right questions at the right time

Polya's Method:

According to Polya's method:

- Do you understand the problem at hand?
- Try to state the problem in your own words
- Visualize or illustrate the problem
- Have you ever solved a problem similar to the one at hand?
- Devise a plan to solve the problem and lay down a strategy
- Break down the problem into segments and then target to solve the segments, ultimately the problem will be solved.
- Look at the problem in different ways
- Implement the plan that you have devised
- Reflect

Polya's method is a discovery based learning method and it says,

"Segment the problem and identify the mental operations involved in it".

Mental operations include:

- Visual
- Verbal
- Logic
- Deduction

An article written by Mayer and Marino suggested the use of multimedia in this regard;

- Verbal Medium
- Visual Medium
- Combination of the two media

Mayer and Marino emphasize to integrate both verbal and visual media to increase the depth of understanding.

Lesson No: 7

Topic: Problem Solving Through Visualization

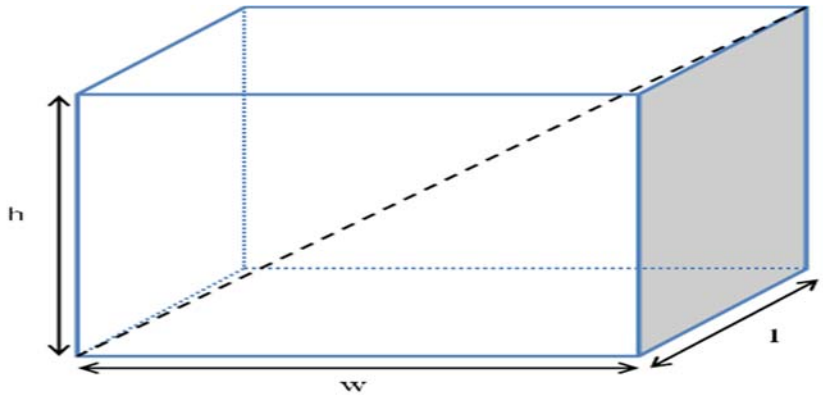
While solving a problem, first of all see if you understand the problem, the wording of the problem, what inputs of the problem are. See if you could comprehend the given data, what kind of output is required and can you express this problem in your own words. Moreover you should know what outputs you want to get. How is the output related to the input which is given to you. Can you create a visualization of that problem? Visualization is very important as sometimes it provides many hints to solve that problem. Polya, in his book, "how to solve it" has also explained the plan to solve problem. Ask yourself these questions: have I ever solved this kind of problem before? Can I use the same plan in this problem? Is there any modification required? Reflect on the whole process at the end. In short, these points are:

- Do you understand the problem
- Try to look at the problem from different angles
- Devise a plan to solve the problem
- Reflect upon the whole process

We may call this the 'Polya Method'; Polya method can be applied in our daily routine life. We should follow the above steps to reach the solution to a problem. In this module, two problems are discussed and you are supposed to solve them. The common thing is that both are related to solid geometry; they are, three dimensional problems. You can solve these problems with reference to the prior knowledge of two dimensions,

Problem: 1.

A three dimensional rectangular box is given;



And we want to find out the diagonal of this box. Now the height, width and length are given. We can derive an expression in terms of the diagonal. So ask yourself, "Do I understand the problem? Can I visualize it? You can give the example of the classroom as a rectangular box. Prior knowledge about such problem, that in plain geometry we have a formula to find out the diagonal. This is not a problem in three dimensional geometry. Try to find out the intermediate step to find out the solution. Now you have understood the problem, take the help from prior knowledge. You have a plan, the issue is not that to find out the solution, you have to visualize the problem for understanding, then make the plan and try to find out solution.

As you have solved this issue, now the rectangle class room collapsed in two dimensions, so can you take help from the pervious knowledge? You can change the units from feet to meters. Is your answer same? The answer should be same. If you have solved the pervious problem, then you can easily solve this problem, the pervious one became the prior knowledge of the learners. It is very important for students to know a method to solve a problem rather than just knowing its answer. In short, if students have the ability to solve the problem of a rectangular box, they can solve the problem of a classroom as well. They find out the diagonal of the box through deriving an equation. That equation is the prior knowledge to solve the next problem. Prior knowledge comes to mind immediately when solving a problem.

Example:

What is the sum of first 100 positive consecutive odd numbers?

Solution:

Step: 1 Understand the problem

Do you know what the words mean?

Odd numbers are 1, 3, 5 . . . . and sum mean to add.

1+3+5+…+? *(The first thing you need to understand is what the last term will be, so you will know when you have reached 100 consecutive odd numbers.)*

1+3 is two terms.

1+3+5 is three terms.

1+3+5+7 is four terms.

It means as if the last term is always one less than twice the number of terms. Thus the sum of first 100 consecutive numbers is 1+3+5+7+…..+195+197+199 *(This is one less than 2(100)*

Step 2: Devise a plan

The plan we will use is to look for a pattern:

1=1	*one term*
1+3=4	*Sum of two terms*
1+3+5=9	*Sum of three terms*
Do you see a pattern yet?	*If not, then carry on*

1+3+5+7=16

1+3+5+7+9=25

Step 3: Carry out the plan

It looks like the sum of two terms is 2^2; of three terms is 3^2, of four terms 4^2 and so on. The sum of first 100 positive consecutive odd numbers therefore seems to be 100^2.

Step 4: Reflect on it

Does $100^2 = 10{,}000$ seems correct?

Let's focus on:

Computer Science (CS) Education in High School and College Level

- What is being taught?
- What is the reason for teaching it?
- How is it being taught?
- The sub-modules will cover areas of
- Pedagogy
- Curriculum
- Benefits of teaching computer science
- Established pedagogy
- Misconceptions
- Different points of view about pedagogy and curriculum of computer science
- Case studies

Before focusing on the above mentioned points, let's reflect on a quotation:

"School learning should focus on the structures of disciplines, to learn structure is to learn how things are related. Our schools may be wasting precious time by postponing the teaching of many important subjects. The student should be encouraged to develop the

intuitive and analytical skills by engaging in active scientific inquiry. Interest in the material to be learnt is the best stimulus to learning." Bruner

More on the above quotation:

Active scientific inquiry is very important and units developing this skill should start at the 6th and 7th level. We have seen many students who can solve the problems given in their textbooks, however, if we ask questions related to the book but not from the book they stagger This is because they rote learn; they learn how to plug and chug the formulas but do not understand the concept behind arriving to the solution.

Curriculum is very important. If your learning outcomes are related to memorizing then it is not discovery based learning. For example, simple questions like what is motherboard, what is CPU are just to check the cramming ability of students. It means curriculum should be challenging, it should be like to discover something. If the curriculum is rote learning, then there is little or no space for pedagogy. The question is of appropriate curriculum and appropriate pedagogy and the effectiveness of discovery learning is required in Computer science discipline at school level. In short,

- The curriculum must be challenging
- We need to have a right mix of pedagogy and curriculum

The question arises in our mind, what is the basic objective to teach computer science at school level. The issue is that how students can be motivated towards computer science and what things repel them to learn computer.

These are critical issues which are in compute science education,

- Whether students are getting the true picture of science.
- Why a little percentage of students are opting for CS education despite the availability of number of CS related job opportunities in the sub-continent
- The enrollment of girls and minorities in CS education
- Are we projecting the right image of CS in school and college level student?

Here we will discuss some studies related to computer science:

www.acm.org (Visit the link ……. suggested)

International Computer Association discussed the reports related to the Computer Science Curriculum. What kind of CS Curriculum should be there for the learner at the age of 12? They have further thrown light on the reports, implementation and results.

Go to the following link for reports:

The New Educational Imperative: Improving High School Computer Science Education

http://www.csta.acm.org/Communications/sub/DocsPresentationFiles/White_Paper07_06.pdf

http://www.csta.acm.org/Communications/sub/Reports.html

You can see that this association is not only working in Pakistan but members from the whole world support it. They discuss the status the CS industry and education, the future of CS, and are we preparing our children accordingly? Here is the summary of it:

Firstly, they define Computer Science.

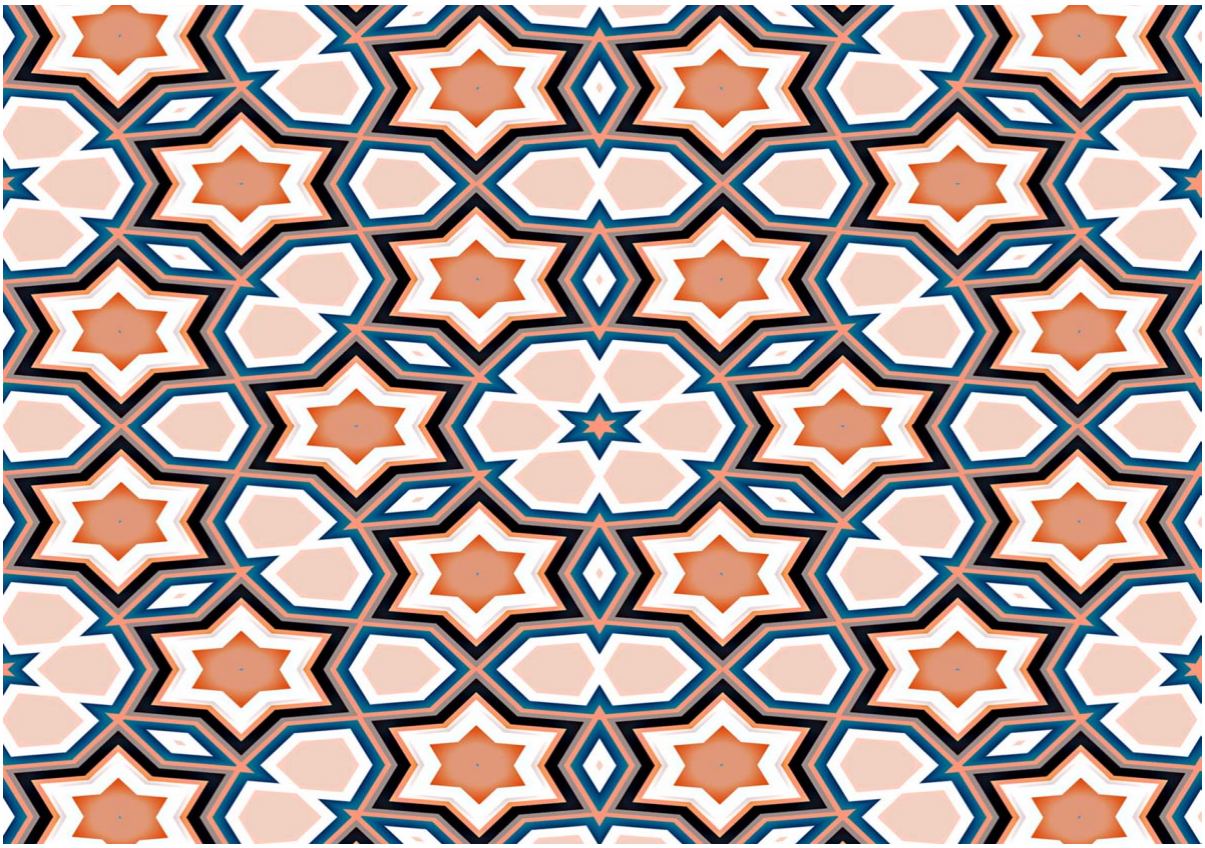
What is CS?

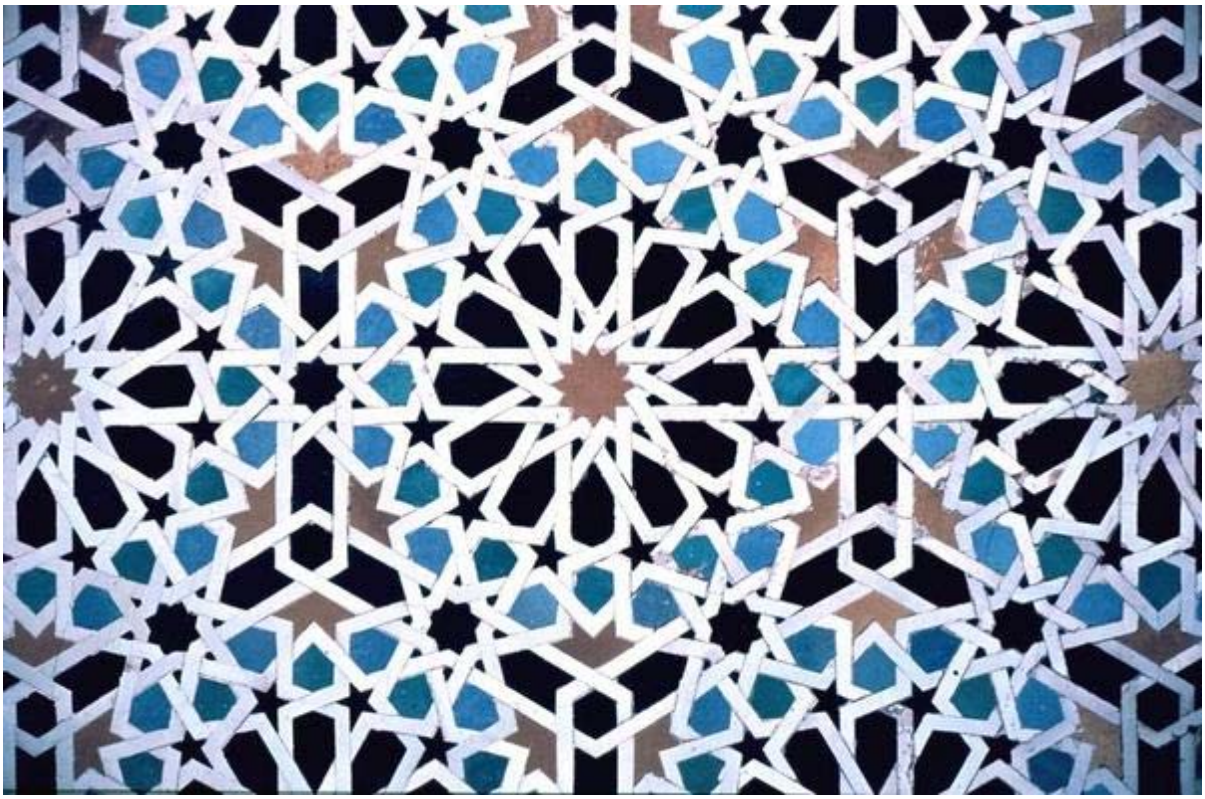
Philosophical questions that arise with its study, it is not just programming but the whole set of concepts and processes that assist in the development of computer systems. It is a study of computers and algorithmic processes. One of the most important, relevant and useful academic disciplines with an immense impact on modern life. It is important for survival and for thriving in a modern world.

Think and discover about the problem solving processes, what happens in our mind and what should happen in our mind to think and discover. CS addresses this problem and we are trying to do the same in this course, when we solve any problem, what kind of processes are going in our mind or what kind of processes should not be in our mind while discovering a problem. The CS study in itself is creative. So the teaching of this subject should be creative too. If we do activities which condemn the creativity we are then going to do injustice to this subject.

In ACM they have discussed the best practices; the one best practice for teaching programming is **"pair programming".** While programming many mistakes happen, students become bored because of it. The pair of two students can be taken from high school or upper level. One gives the instruction and the other one applies those instructions. It is like that, one person is solving algorithm and the other one is providing instructions and feedback. It is a new paradigm of learning which we took from the Computer Science.

If we think about Polya’s method, as he discussed the four stages, then one student should specialize in one stage and the second one should specialize in second stage. They can exchange their roles. In this way learning can be socially dynamic. Moreover, motivation and collaboration are introduced .It depends on the teacher to introduce the team work or group computation or other strategies. For example, if you want to teach recursion, repeat until, fall loop, or rotation. Let us start with graphical patterns, building blocks of graphical patterns are very easy, and you can make this with the help of simple geometry. Now you can give these building blocks to the students, they will repeat, rotate, in different directions, so different kinds of graphical patterns will be created with this activity. Take a look at these few graphical patterns that are made by using simple building blocks:





If you want to avoid student boredom while teaching them CS, give them visual for playing and then ask them about the role of that visual for a particular CS topic. In this way, student can play whole day with that visual or in free time with his friends. As **Bruner** talked about the revolutionary curriculum, take one concept from the computer science logic and handle in a way that students want to play with it and you provided them the discovery opportunity. It is important that the curriculum allows discovery based learning, and can be linked with children’s imagination, creativity and play abilities.

As in Pakistan, every student does not have assess to computer, so students will enjoy learning while making shapes with hands and this can be equally applicable for the students who are not computer friendly. The students who have computer they can make it on computer. Algorithm and graph theory do not require computers for learning, you can even teach them without a computer.

Recommendations of ACM

- Problem solving skills
- Fundamentals of CS
- CS as analysis and design

In USA, very few standards were followed,

- Lack of attention on developing concepts and capabilities.
- The emphasis is on skills and terminology

The major short coming in USA is of concept understanding.

Same is the situation in Pakistan; Concept focus is far less than the focus on skills and terminology.

Lecture # 08

Topic: Recommendations about CS education in high school and college level in Pakistan

Review of the previous lesson:

- ACM's recommendations
- Problem solving skills
- Fundamentals of CS
- CS as analysis and design

When we see computers, the first thing we visualize is its hardware. **Hardware organization** includes:

- How the computer works
- The physical components of a computer like keyboard, mouse, CPU, monitor etc.
- One on one instruction and how it works with the memory.

It is very important to study hardware in order to understand the computers. Second thing is **Computer software and programming:**

- Operating systems
- Application programming

The third aspect is of **theory and algorithms:** It is a very important aspect on which the recommendations of ACM were:

- It is neglected in most of American Universities; it includes graph theory, algorithms and discrete math. It is a very natural approach in minds on which we want to solve a problem without using computers. Try to express the solution of problem very systematically and when it is decided that the solution is appropriate and efficient then code it in computer program to solve problems.

Forth aspect is the **artificial intelligence:** How the human brain works and how the computer machine can be programmed to think intelligently, scientifically, rationally and irrationally.

In the book "The emotion machine" by Marvin Winsky, it is written about artificial intelligence that:

"Knowledge is represented in different ways:

- Mathematical mind
- Connectionist mind
- Linguistic mind
- Conceptualist mind
- Statistical mind" Here Marvin Winsky has quoted Aristotle:

"A person might describe a house as a shelter against destruction by wind and rain while another might describe it as stones, bricks and timber, but there is a third possible description

which would say that it was that form in that material with that purpose or hind. Which then among these is entitled to be regarded as a genuine physicist? The one who confines himself to the material description or the one who restricts himself to the functional description. It is not rather the one who combines both in a single formula" Aristotle.

The above quotation focuses on the difference of rote learning and meaningful learning. Our brain is programmed to tackle instruction. According to Minsky:

- Make different representations of the problem
- Reformulate the problem
- Have we ever solved a same or similar problem before
- Divide and conquer
- Solve a special case and then see if it can be generalized

The brain at this time:

- Goes from Abstract to Details
- Goes from Details to Abstract
- Checks for any logical contradictions in the solution
- Visualizes problem

Similarly, Polya has identified the steps of "How to solve a problem":

- Do we know the inputs and outputs of a problem?
- Can we visualize the problem and put it in different forms?
- Have we solved a similar problem before?
- Can we break down the problem into smaller chunks?

Professor Skiena in her book "Algorithm Design" has identified the following steps to solve a problem:

- Do I understand the problem with different perspectives?
- What are inputs and outputs?
- Did I solve a similar problem before?
- Can I find a special case which is easier to solve?
- Can I find a building block which when repeated several times solves my problem?
- Can I divide the problem into smaller parts?

The difference in both writers' perceptions on solving a problem:

Marvin Lee Minsky	**Skiena and Polya**
How our brain solves a problem	How we should think or solve a problem

- Professions of all the above are different but their work is same i.e. good quality of thought. Non psychlogists did this by trail and error. Minsky discover it through experimentation that these 6 are the basic principles to define human thinking. He says that if full potential of human thinking must be used, failure in problem solving occurs when we do not use all these principles to solve a problem. So,

- Divide the goal into sub goals and facilitate the students to discover the sub goals and eventually they will be able to discover the main goal

- Provide them building blocks

Areas in the field of CS:

- Thinking, problem solving, algorithms
- Programming
- Hardware

Sub module:

In this module we will discover about computer organization and hardware.

Read the following article for more information on this area:

Bonco and Thiniazi from University of Verona Italy presented the paper titled:

"One step further the ACM k-12. The final report. A proposal for level one computer organization for k – 8 students"

In short, in this article they try to teach the students through story telling. It tells that CPU is the king and controlling realm of whole computer.

Story telling:

- Storytelling is a mega framework that develops in very young children for holding information.
- Every story has a beginning and an end.
- It is sequential.
- The sequence of a story is logical or quasi logical.
- There are characters in a story.
- A story has interlinked connections.
- A story can have one or a number of goals.
- Creative

- Self-expression
- Self-discovery
- Fantasy
- Excitement

Provide them good and attractive building blocks which trigger their natural sense of play and experimentation. Now here are some challenges:

Challenges as an Instructor

- How to make the building blocks
- How can we create excitement, interest and motivation for discovery among students
- How to follow the ACMs recommendations

Lecture # 09

Topic: “How sets can be taught through Discovery Based Learning (DBL)”

Sets and discrete objects were included for the first time in the F.Sc. syllabus in 1967; however, the short coming of the content design was that students could not understand the importance and usefulness of these concepts in their daily lives. In other words, they failed to apply these concepts in real world scenarios. By comparing the textbooks of Punjab, Baluchistan, KPK and Sindh, we come to know that they have added the topic of groups with sets which is its abstract application. The topics algorithms, graph theory etc. have significance in computer sciences however, they are taught in mathematics in detail at the F.Sc level. Most of the students are not going to become mathematicians, only 1% of the whole class might choose this field. So, mathematics should be taught to the students in a way that they can use it effectively as an applied mathematics tool in any field of life.

Discrete mathematics does not involve calculus and analytical geometry instead it includes topics like:

- Set theory
- Functions
- Relations
- Operations; sorting searching etc.
- Propositional Logic and Logic Gates
- Graph theory
- Algorithms
- Group theory

Concept of sets:

To put (something or someone) in a particular place.

Examples:

- A set of people who wrote pedagogically good books on mathematics, is a small set.
- But a set of literary books written in Pakistan has many things involved in it.
- A set of concepts difficult to understand in graph theory and group theory
- A set of girls in 7^{th} grade who do not like to study Mathematics or Biology
- A set of instructors friendly to new teaching ideas

So, what is a set?

- A set is any well-defined collection or list of distinct objects, e.g. a group of students, the books in a library, the integers between 1 and 100, all human beings on the earth, etc.
- **Visualization of sets:**

The things in set which are visible, like

- A set of toys of children

Sets can be of:

- Natural numbers: 0, 1, 2, 3, 4, 5 ……..
- Even Numbers: 0, 2, 4, 6, 8 …….
- Odd Numbers: 1, 3, 5, 7, 9 ……..

Subset:

A set that consists of some elements of another set is called a subset of that set. For example, if B is a subset of A, then every member of set B is also a member of set A.

This knowledge of sets is our prior knowledge which helps us to understand the concept clearly. For example,

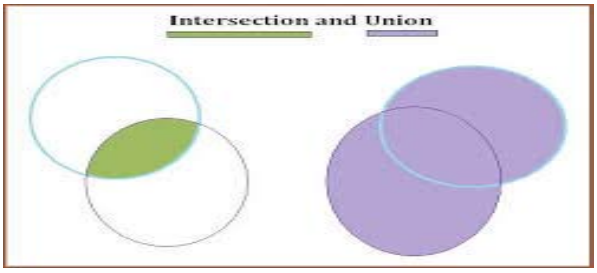
- Is the set of even numbers a proper subset of natural numbers? yes
- Is the set of odd numbers a proper subset of natural numbers? yes
- If we put together odd and even numbers, would we get natural numbers? yes
- Can we quantify even and odd numbers? yes
- Can they be compared with each other? No, because it is the proper subset

By asking such questions, learning in classroom can be made exciting, discovery based and interesting.

Operations on sets:

- **Intuitive concepts in sets**
- **Non- intuitive concepts in sets**

  It is the responsibility of the teacher to know which things are intuitive and which are non-intuitive while teaching concept of sets as well as what extra effort is required to make the topic interesting for the students. Operations on sets (union and intersection)



Example: 1

Friends of Ali and Nariman: there are two sets, one is of Ali’s friends and the other is of Nariman’s friends. They are combined by taking union.

Example : 2

Toys’ belonging to Nariman is a set.

Example: 3

Toys’ belonging to Ali is a set.

Example: 4

Toys’ gifted to Nariman by her mother is also another set.

Example: 5

Common toys between Ali and Nariman: here intersection of their toys is made to make a set of common toys.

Example: 6

Toys’ belonging to both Ali and Nariman is a set.

Example: 7

Toys gifted to Ali and Nariman on their respective birthdays by someone is another set.

Example: 8

Toys’ of Nariman broken by Ali is a set.

Example: 9

Can we add toys of Ali with that of Nariman? So, it will be done by union. So tell the students clearly that union means adding both the sets. Whereas the common toys between Ali and Nariman will be added only once and not repeatedly.

Example: 10

Can we subtract toys of Ali from Nariman? If it is not a null set then intersection can be done to subtract the toys of Ali from Nariman. It will make another set.

Example: 11

Can we multiply friends of Ali and Nariman with the set of Ali and Nariman toys? It does not make any sense and it is not intuitive.

Example: 12

Addition and subtraction are intuitive as far as the union and intersection of sets go. Here we can consider graph theory as well because relations are at the heart of graph theory as well as group theory.

For example: Set A and set B are two sets, find the product of set A and set B.

- Multiplication of two sets in not intuitive. If set A is (1,2,3,4) and Set B is (5,6,7,8), it is possible to get the multiplication. It is an operation but its meaning and sense is not clear. So product of A and B is also a set. Secondly, any subset of this is a relationship of A and B.
- What is the product of two sets? For example, A is a set of literary books in Urdu and Persian and B is the set of animals and birds in this world.
- What is the product of set A and set B?
- What is the product of set B with set B.
- Is the product of two sets also a set?

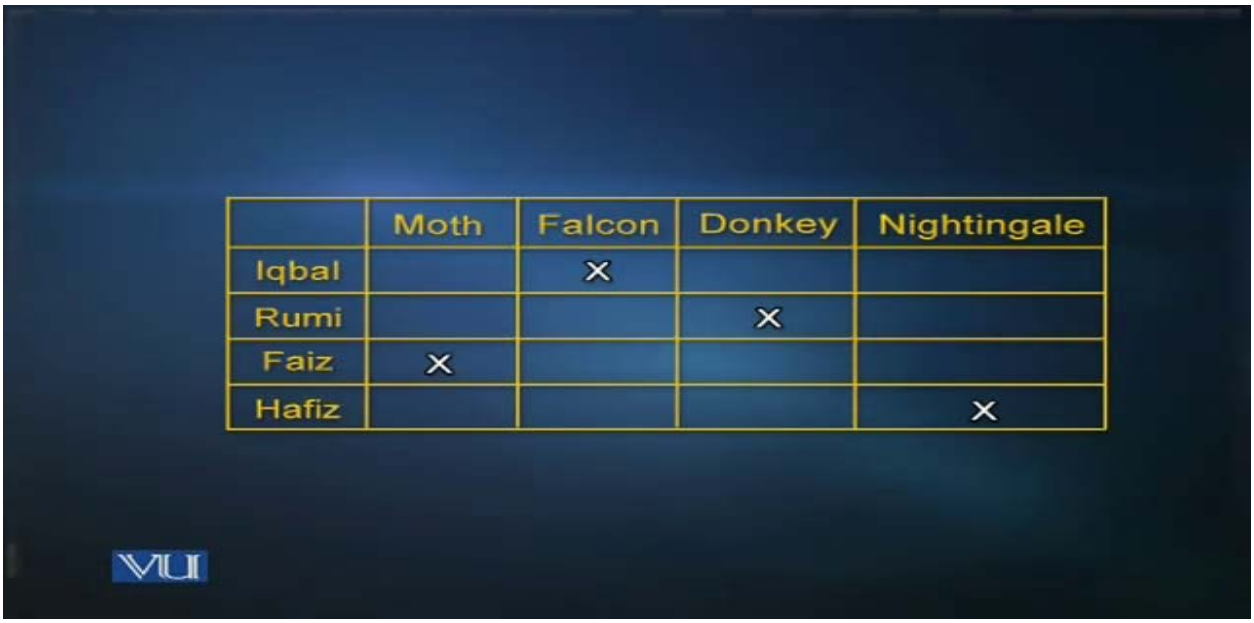
What is the product of set A and set B?

Now here, the paired set will be made and order must be kept in mind i.e. first a book is added in the set then an animal. Similarly all books and animals are paired in a set. Take four books of poetry and four birds in set A and B respectively. Now it is possible to pair them. Which poetry book has an inspiration of which bird in the poetry? Now here is the relationship between books and birds associated with these poetry books.

Representation of the above example can be:

- In the form of a story: it can be told that the book of Iqbal’s poetry has an association with eagle, and in this way a paired set is formed.
- Ordered pair: here the order of making pairs must be kept in mind that firstly, the book will be selected and then the associated bird or animal
- Make the picture of the books and show the association with birds and animals through directed lines. Here one book can be associated with two birds so two directed lines from a same book will associate with two birds.

- Fourthly, it can be represented through computers. It can be presented in table where vertically names of books are mentioned and horizontally the names of animals and birds are mentioned. Students can fill the table accordingly.



	Moth	Falcon	Donkey	Nightingale
Iqbal		X		
Rumi			X	
Faiz	X			
Hafiz				X

There is always a relationship between sets and subsets of the two original multiplied sets. When we define two sets and ordered pair is driven through these two sets; make sure that the first element of ordered pair is from set A and second element of ordered pair is from set B.

Conclusion:

The students often surprise us with what they already know or half-know. By using the ‘discovery technique’ we learn more about their knowledge and abilities eliciting information from them rather than telling things to them. To improve math instruction "schools must place a much stronger emphasis on mastering basic math skills and standard algorithms. Math curriculum guides must require the learning of standard algorithms, and textbooks must contain clear, systematic instructions as to their use.” First teach the students about concept of sets and then give them such examples where students can explore the relationship between subsets and sets.

Lecture # 10

Topic: “how the human brain works, the biology of brain as studied by a neurobiologist.”

Recap:

So far we have discussed aspects of

- Discovery learning
- Problem solving
- Opinions of different psychologists, educationists and researchers about problem solving and discovery learning

We have also taken a look at the good practices and opinions of

- Marvin Minsky.
- Steven Skeina
- George Polya
- Harvard Calculus Consortium

Let’s start with a question:

Why does an object float on water? The answer to this is that if the density of the object is less than water then water has the power to push the object up to float, if the object is so much denser than water, then the object will have the power to break through water and sink, Now we ask ourselves the question, why does a duck float on water? This is so, because there is a special uropygial gland near the tail of the duck from where some oil is secreted; this oil covers its wings in such a way that they become water proof.

When this type of information is presented to the students through visualization or some example, it is stored in their long term memory. Once a student Mary was facing difficulty in learning about proteins. She noticed an oil film floating on water. She also saw a duck floating on the water in a pond. She had the prior knowledge of how ducks float on water. She related that information in learning about proteins. Both these things got interconnected as in when an oil layer comes to an object it starts floating. Professor Zull, Director in center for innovation in teaching in education, says that Mary’s connections were about ducks, oil, water, floating and sinking and all this was a network in her mind. Her neuronal networks also included proteins and biochemistry which she was unable to understand. When some of these networks began to fire at the same time, i.e. when she saw the duck on the pond while she was thinking about proteins. These two networks became physically connected.

James E. Zull in the book “The Art of Changing the Brain” says that better understanding of brain function will promote a more flexible and varied approach to learning. Educators can use knowledge about the brain to enhance pedagogical techniques. For example, if we want to teach students how to read? A teacher must know all the adult processes of the brain or reading so that

he can provide the sub-tasks of reading to the students accordingly. So that they can quickly achieve the adult brain reading stage. A teacher should also know which pedagogical skills violate the brain mechanism from learning. The author says that brain is designed through evolution and in this way it can learn through experience. Learning means changing the brain. Teaching is the art of changing the brain in a natural fashion. Neurons in the brain are similar as the connections of concepts in the brain. The writer further recommends:

- Biological understanding of learning is very important
- To know, why we learn
- Why we do not learn something sometimes?
- What are the problems of learning biologically?
- Learners construct their own understanding by building on prior knowledge. Whatever they can connect will be learnt. This is no longer a theory of learning.
- Connections in the neuron network → connections between concepts.
- Understanding the concepts of neuronal network and synapses' (where two neurons connect to each other) change gives credibility to constructivist theory of learning.
- Knowledge cannot be transferred. It can only be constructed and discovered through a learner's personal experience.
- A great deal of brain is dedicated to physical relationships in space. It has a great capacity to create and remember images. What does that imply? There are three things, prior knowledge, image/ visualization, and connections. The more the connections, the more is the learning.

"The single most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." David E Sobel

The above mention quotation is on learning, but if it is quoted in biological context. It would be:

- The single most important factor in learning is the existing network of neurons in the learner's brain. Ascertain what they are and teach accordingly.
- Watch for inherent networks, natural talents and encourage existing practices.
- Arrange for firing together. When two knowledge states are activated together again and again they build connections among themselves.
- Understand the prior knowledge and experience of students and then facilitate them to connect the current concepts or topic with their prior knowledge.

(Read about insight and analogy learning……. suggested)

In order to help students discover something, make very small building blocks.

Read the following article for further study

A Model for High School CS Education; the 4 Key Elements that make it.

Department of Education in Technology and Sciences

Summary of the 4 key elements is:

A well-defined curriculum including written course textbooks are requirement for a mandatory, formal CS teaching license. Teacher preparation program including at least a Bachelor's degree in computer science, certificate study program.

In Israel, there is a national center; this national center is considered as a professional home for all Israeli computer science teachers. It's a course they are teaching and ongoing training by forming learning communities and organizing different activities, annual conferences, workshops etc.

Posing a problem:

Problem posing is an art, which an instructor must master.

The teacher must keep in mind the following while posing a problem to students:

- The learner should appreciate the problem and could identify the input and output.
- Move from simple to complex
- Take into account the prior knowledge of students
- Divide and conquer is a powerful tool to solve a complex problem.

Temperament of Discovery:

- High tolerance for errors, failures and exhibit patience and dedication to solve the problem.
- Don't jump to the solution; rather master the method to solve the problem.
- The time consumed in discovery learning is worthwhile.
- Allow students to construct their knowledge through DBL
- Build more and more connections in their minds.

Lecture # 11

Topic: “The role of images and pictures in learning”

In the book, “The art of changing the mind, enriching the practice of teaching by exploring the biology of learning” the writer Prof. Zull says that:

Better understanding of brain function will promote a more flexible and varied approach to learning. Educator s can use knowledge about the brain to enhance pedagogical techniques. Learning means changing the brain. Teaching is the art of changing the brain in a natural fashion.

More he says that our brain is basically a seeing brain. It means that “A picture is worth a thousand words.” There are also some medical studies in the book. i.e. Physical objects in the world contain conceptual relationships and so then do the neural networks of our brain. Whenever you saw something, any simple object, you will have a complex, logical relationships encoded in mind about that object. People can recall seeing hundred or even thousands of pictures even when they have seen the pictures for only a few seconds. Researchers in this field have even suggested that there is no upper limit to the number of pictures that the brain can store. Other studies suggested the astounding result that the human brain can search for more than 50,000 images per second in long term memory.

As in Chemistry and Biology, demonstration method is followed to teach. According to Harvard calculus, every concept should be presented:

- Graphically
- Numerically
- Verbally
- Analytically

For example, Newton’s laws include verbal explanation, graphical representation, numerical questions to verify etc. Exponents give dramatic images of growth if we make their graphs, attrition, explosion and fading away. So, use visual aids to help students in DBL. The word teacher is derived from the word teacan, which meant ‘to show’. So the basic job of the teacher is to show something related to the concept to the students while teaching. Teacan is a Germanic word, when it is changed to Latin it becomes’teacher’.

The book of “Conceptual Physics” is taught at High school in United States, almost 2/3 of the teachers recommend this book. It is one of the most popular books in United States. Since defining this course 30 years ago, Paul Hawirtts’ best selling book continues to be the benchmark book that two thirds of professors use and by which all others are judged.

Why this book is very famous:

This book is famous for engaging readers with analogies and imagery from real world situations that build a strong conceptual understanding of physical principles ranging from classical

mechanics to modern physics. This book has lots of cartoons and great everyday examples. Almost every problem is demonstrated by a cartoon. An excellent way to help students visualize a problem.

Similarly, in the book "Algorithm Design" by Stieve, S. Sakiena, it is also said that if you want to solve a problem, draw its graph.

The importance of visual aids in teaching and learning:

Here a problem is presented in the graphical form Infact, posing a problem is also an art. Pose a problem in a way as it is a part of your daily life. When problems are presented in such a way, the connections between your prior knowledge are built rapidly. So it will become easy to visualize and build graph of it.

Problem: 1

Salma is working in an office. Her husband name is Aslam, she invited some of her female colleagues at home. She was busy in cooking when her friends arrived. Her husband received and welcomes them. Aslam shaked hand with some of her friends so Salma get curious on it.

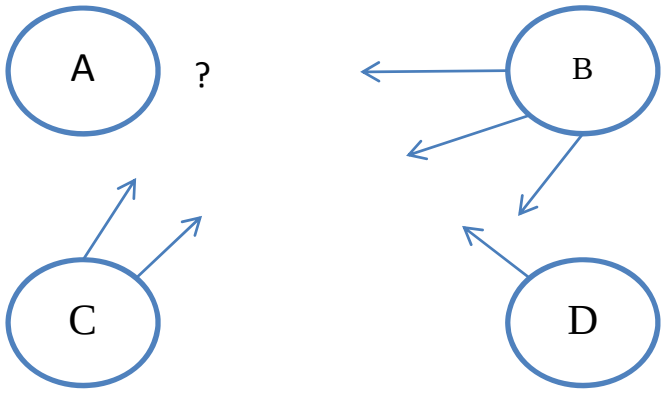
Aslam is represented by A in the below picture and salma's friends with B, C and D.

A B C D

Salma asked her friends with how many people they shake hand today. Her freids replied which is presented in the table below:

Person	No. of Handshakes
A	?
B	3
C	2
D	1

Now we had the following information that B shake hand with 3 people, D with 1 and C with 2.



It is a very common problem, if it is visualized as shown in the pictures above, it would become easy to solve. Professor Zull in his book "The Art of Changing the Brain" says that

- Our brain is a seeing brain
- The role of images and pictures in learning
- Moreover he says that students do not reflect on their results. Reflection actually is very important in learning. E.g. students apply the formula without understanding and even not reflect on it. Like to calculate the diameter of earth. If the diameter is in cm then it is not true and one must reflect on it to apply the right formula.
- He also says that there is no need of reflection in exact mathematics, rote learning and language processing.
- Reflection is important in visualizing, making comparisons, searching answers to why, how and why not?

No reflection takes place in:	**The brain reflects while:**
• Exact Mathematics • Rote Learning • Language Processing	• Visualizing • Making comparisons • Searching answers to why how and why not

Reflection:

Professor Zull in his book says that putting an answer in perspective is basically a reflective activity. E.g. calculation is basically a reflective activity. Make students reflect upon the plug and chunk problems that are related to mathematics. There are multiple layers of reflection:

For example,

- Check the calculations again
- Which formula is applicable in a given problem?
- What are the other ways through which the problem can be solved?

Basically reflection is searching for connections between different concept, events or whatever; we start with simple concrete experience or problem statement and allow and encourage our brain to search for new connections. Our present experience or problem is connected with what we already know i.e. our past experience. Things have meaning when they remind us of something of the past. When no input is coming from outside, even then reflection is taking place in the brain. Reflection is the key to create knowledge

Lecture # 12

Topic: "How to generate pedagogical content knowledge"

Review of the previous lesson:

- Our brain is a seeing brain
- Brain can identify and differentiate easily when it has visualization aids
- Ingredients for discovery based classroom
- Pedagogical content for partial discovery based classroom
- Images are a very powerful support for thinking.
- The problems which are not intuitive and need reflection

This lecture's focus:

- How to generate pedagogical content knowledge
- Puzzles/problems

In the book, "The Art and Craft of Problem Solving" by Paul Zeitz, it is written that problems and exercises both are different. For example 3126^3=? How will you solve it without using a calculator? Multiply this number three times to get the answer. But the product answer will be large. Time and effort required to solve it is not much intellectual. Our brain tends to look into pattern.

Example 2: $\frac{1}{1}(2) + \frac{1}{2}(3) + \frac{1}{3}(4) + \cdots + \frac{1}{99}(100) = ?$

Our brain always tries to find a pattern. This equation is so difficult to solve and it needs extra time and effort. But if a pattern is made in mind like;

1/1(2)+1/2(3)= 2/3

First three terms=3/4

First 4 terms =4/5

First 6 terms=?

First 6 terms= 5/6

So, if this pattern is followed, answer can be sought through n/n+1. This is a very elegant and easy method to solve a problem.

The author further says that solving a problem is just like climbing a mountain. He identified four steps to solve a problem:

1. Strategy level
2. Tactics level

3. Tools
4. Reflection

Critical reflection is an important part of any learning process. Without reflection, learning becomes only an activity — like viewing a reality TV show — which has never meant to have meaning, but is only meant to occupy time. Critical reflection is not meditation, rather it is mediation in reflection, all the learned material can be gathered about, sorted and resorted, and searched through for greater understanding and inspiration.

If the students apply the right strategy to solve a problem, the answer doesn’t matter. Appreciate the students on using the right strategy, tactic and tool.

Example: Prove that the product of 4 consecutive natural numbers can never be the square of a natural number.

First of all let the students appreciate the problem. Encourage students to solve a problem through multiple ways. Instigate their thought process.

When generating pedagogical content knowledge, never tell the students the exact solution or answer. Make them propose a solution and practice it. Give them the initial strategy:

Strategy

$$1 \times 2 \times 3 \times 4 = 24$$

Product of first four natural numbers is 24 whose square root is not a natural number. Now ask the students the nearest number that can be the square of natural number? It is 25. Ask the students to proceed with the process:

$$2 \times 3 \times 4 \times 5 = 120$$

Now again, 121 is the square of 11. This is also a nearest number but not exact square of a number. If we proceed further, it can be seen that if 1 is added it will also be a square of natural number 19.

$$3 \times 4 \times 5 \times 6 = 360$$

There is a difference of 1 in every equation, now ask the students how to prove that the product of 4 consecutive natural numbers can never be the square of a natural number. Students can see the pattern to solve the problem:

$$1 \times 2 \times 3 \times 4 = 24$$

$$2 \times 3 \times 4 \times 5 = 120$$

$$3 \times 4 \times 5 \times 6 = 360$$

This pattern was the strategy to see the problem very carefully and critically.

If 1 is added to the product of natural numbers, we will get the square. This thinking about the problem to prove comes under tactics

Tactic

$$1 \times 2 \times 3 \times 4 = 24$$

$$24+1 = X^2$$

where x is a natural number OR

$$X^2 - 1 = 24 \text{ OR}$$

We simply assume that it is correct, and then we can try to prove that the product of four consecutive natural numbers is never a square. Can we prove that x^2-1 is never a square of a number? The difference of answers of two squares of natural numbers is never 1. i.e. Square of 2 and 3 and their difference is:

$$2^2 = 4$$

$$3^2 = 9$$

$$9-4 = 5$$

The difference of square of two consecutive numbers is never equal to 1. Let us see the squares of 1 and 2:

$$1^2=1$$

$$2^2=4$$

$$4-1=3$$

Now let's try to generalize the problem:

Four consecutive numbers: n, n + 1, n + 2, n + 3

If we can prove that the product of these is equal to $(x^2 - 1)$ then we are done because we already know that $(x^2 - 1)$ is not the square of any natural number. So, we have to show that

$n (n + 1) (n + 2) (n + 3) = x^2 - 1$

Now, what we are trying to prove is:

$n (n + 1) (n + 2) (n + 3) = x^2 - 1$ OR

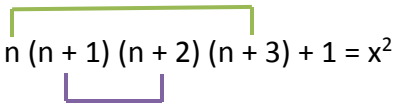
- ⇨ $n (n + 1) (n + 2) (n + 3) + 1 = x^2$ OR
- ⇨ The product of 4 consecutive numbers + 1 = a perfect square

There are different tactics to solve the problem:

One tactic: **factor** the expression!

$n (n + 1) (n + 2) (n + 3) + 1 = x^2$

Our goal is to manipulate the left hand side expression to get a square.



Look at the product of n and n + 3. Now look at the product of n + 1 and n + 2. They're somewhat similar.

- ⇨ $n (n + 3) (n + 1) (n + 2) + 1$
- ⇨ $(n^2 + 3n) (n^2 + 3n + 2) + 1$

We need a common factor so let's try to create that

- ⇨ $(n^2 + 3n + 1 - 1) (n^2 + 3n + 1 + 1) + 1$
- ⇨ $[(n^2 + 3n + 1) - 1] [(n^2 + 3n + 1) + 1] + 1$

Apply the rule $(a + b) (a - b) = a^2 - b^2$, with $a = (n^2 + 3n + 1)$ and $b = 1$

- ⇨ $(n^2 + 3n + 1)^2 - 1 + 1$
- ⇨ $(n^2 + 3n + 1)^2$ which is a perfect square!

Another possible tactic: **substitution**

- ⇨ $(n^2 + 3n) (n^2 + 3n + 2) + 1$

Let $u = n^2 + 3n$

- ⇨ $u (u + 2) + 1$
- ⇨ $u^2 + 2u + 1$
- ⇨ $(u + 1)^2$ which gives us a perfect square

$n (n + 1) (n + 2) (n + 3) + 1$

⇨ $n^4 + 6n^3 + 11n^2 + 6n + 1$

If this is going to be the square of something, it will have to be the square of $n^2 + an + 1$ or $n^2 + an - 1$. Let's try the first case:

$n^4 + 6n^3 + 11n^2 + 6n + 1 = (n^2 + an + 1)^2$

⇨ $n^4 + 6n^3 + 11n^2 + 6n + 1 = n^4 + 2an^3 + (a^2 + 2)\, n^2 + 2an + 1$

Comparing coefficients, we find that a = 3 seems to work

⇨ $n\,(n + 1)\,(n + 2)\,(n + 3) + 1 = (n^2 + 3n + 1)^2$

Reflection

Which was the best way to solve the problem?

For a more detailed explanation of the given solutions, please see pages 4-6 of *The Art and Craft of Problem Solving*, 2nd Edition. Go to the following link to access the book online.

http://kheavan.files.wordpress.com/2010/06/paul-zeitz-author-the-art-and-craft-of-problem-solving-2edwiley20060471789011.pdf

Lecture # 13

Topic: “Teaching Probability”

Topics to be covered in Lecture 13 are:

- Math’s Education
- Experts’ opinion about Teaching of Probability and Problems of Learning in Probability
- Khan Academy

Different writers have given recommendations on teaching Probability to students as Probability is one of the most ill understood topics or subjects at any level of schooling. Polya discusses the problems that are faced during teaching of mathematics and problem solving. Some suggestions given by different writers are:

1) **Visual and Verbal Presentation:** In Harvard Calculus the problems faced by the students in the US are discussed and it explains that when teaching a mathematical concept to students it must be presented visually and verbally in the form of graphs or tables so that students can retain it for a longer period.
2) **Using Images:** Hyden elaborates the same concept when he says that our brain learns more by images and this kind of learning can be retained for a longer time.
3) **Socratic Method of Dialogue:** Freire advocates the Socratic method of teaching and encourages dialogue between students and teachers on a given topic.
4) **Mapping or Making Connections:** Novak advocates the concept of mapping or making connections between concepts as a key element in understanding probability.

Here are the references of some books and writers who worked on probability and have given their recommendations on teaching of probability. Problems faced during teaching of mathematics and problem solving is identified by G.Polya in the book “How To Solve It.” Second book is of Harvard Calculus, this book addresses the problems faced by students in USA while learning. The book discusses that while teaching a concept to the students always present it visually, verbally, in the form of graphs or table so that students can keep it in mind for longer a period of time, as “a picture is worth a thousand words.” “On the Biology of Learning” by Holger Hyden also discussed that our brain is sense lush and learns more by images and this is a long term learning. “Pedagogy of the Oppressed” By Paulo Freire, in this book it is said that Socratic Method should be followed for learning. There must be dialougue and question answer session. Similarly, Joseph, J. Novak presented the concept of mapping. And making connections between the concepts. Marvin Minsky in “The Society of Mind” also identified problems of learning.

To teach probability start with:

- Narration

- Story
- Verbal Description

Definition of Probability:

The extent to which something is likely to happen, occur or be the case.

Examples of Probability:

Some examples of probability include:

- There is a 20 percent chance of rain tomorrow.
- Based on how poorly the interview went, it is unlikely that I will get the job.
- Since it is 90 degrees outside, it is impossible to snow.
- After flipping this coin 10 times and having it land on heads 8 times, the probability of landing on heads is 80 percent.
- There is a 50 percent chance of snow tonight.

Toolbox for Teaching Probability

- Probability Tree
- Grid of Possibilities
- Table of Possibilities

Provide the students with such toolbox or interface while teaching probability so that they can solve or look through the problem intuitively. These are the standard tools or techniques which are very useful in teaching probability. Sometimes, there is a need to interconnect these tools i.e. tell them a linguistic story, then make a grid or table to show the maximum possibilities of occurrence of something.

There is a need to over emphasize the story telling phase to teach probability. The more flexible, well connected your knowledge about a concept is, the more useful it will be. In reference to the article mentioned below,

"On the use of paradoxes in the teaching of probability."

Talma Leviatan

Tel Aviv University, Israel.

Access the article from this link for further study:
https://www.stat.auckland.ac.nz/~iase/publications/1/6g3_levi.pdf

It is written that:

Conventional textbooks and classrooms do not provide a learner sophisticated general strategies for solving a problem. In addition to standard techniques and models, students also need a good "toolbox".

We are all aware of the fact that probability theory is infested with many misconceptions, fallacies and pitfalls. To quote Laplace: "The mind, like the sense of sight, has its illusions, and just as touch corrects those of the latter, so thought and calculations correct the former... One of the great advantages of probability calculus is that it teaches us to distrust our first impressions". Dealing with them should be an integral and routine part of any probability course. The problem here is that students tend to accept whatever they are taught in mathematics classes as truth (once they understand it, of course). Without always noticing that it actually conflicts with their previous intuitions.

Since their intuitions remain unchallenged, when those students encounter, later on, a real life situation in which they have to make a probabilistic judgment, the chances are that they will use their previous intuitions rather than their formal studies. My experience therefore is that it is best to confront all these difficulties and clear the mind of potential conflicts.

Conclusion of this paper is:

Finding misconceptions, addressing those misconceptions, dialogue, discussions are a prerequisite to teaching probability.

- Start with an unintuitive problem or problems and conduct discussions.
- There should be a problem independent common toolbox.
- Reflection.

Similarly, in the book "How to Solve It-Modern Heuristics" it is written that observe intuition while learning about probability. If the confusions in mind are not confronted, then they become permanently misunderstood in the minds of students.

Khan Academy:

http://www.khanacademy.org/

Salman Khan when introducing of probability:

- starts with a story or description instead of a definition;
- teach through example so that rote learning is minimized;
- visualizes the story;
- uses simple, everyday prior knowledge;
- Uses visualization technique in a way that as the complexity of story increases, it is depicted in the picture as well;
- Uses probability tree, grid, table, story telling;
- Moves from simple to complex and make connections between them;
- Does not start with formulae or theorem.

Khan academy lectures are based on constructivist approach and they are linked with problem solving. You can view the lecture of Khan Academy here:

https://www.khanacademy.org/math/probability/independent-dependent-probability/old_prob_videos/v/probability--part-1

Lecture # 14

Topic: “Addressing intuitive problems while studying probability”

Problem: 1.

Nasir has 8 children. The first 7 babies are boys, what is the probability that the last baby is a boy or girl?

Problem: 2.

Nasir has 8 children. 7 out of those 8 are baby boys; what is the probability that the 8th child is a baby boy or girl?

Are these two problems same?

Intuition on these problems is that there will be 50% probability of the last baby to be boy or girl. But it is not true. Let’s make this problem much easier; for example:

- What will be the probability of having 2 boys in a family of 4 children?
- What will be probability of having 1 boy and 3 girls in a family of 4 children?
- What will be probability of having all boys in a family of 4 children?
- What will be probability of having all girls in a family of 4 children?

These all problems are interrelated, are the probability in each question the same? Determine the search space and figure out a number of possibilities to solve a problem. As we are taking example of 4 children in a family, if the search space is determined then it is easy to solve a problem, the search space (full range of possibilities which include imagination and understanding as well) for them will be: 0 represent girls , 1 represent boys (these numbers are given to them without any reason). Boys can be represented by 0 or they can be represented by the numbers 1,2 etc. So, the possibility that 2 children are female and two are male of the family of 4 children can be seen through the search space given below and possibilities are highlighted in red:

0 – girl, 1 – boy

0000	0001	0010	0011
0100	0101	0110	0111
1000	1001	1010	1011
1100	1101	1110	1111

There are six possibilities out of 16 that 2 children are male and 2 are female. They can be younger or elder, youngest or eldest. The probability can be calculated by dividing 6 by 16.

Similarly, the possibility that 1 child is female and other three are male of the family of 4 children or 1 child is male and other three are female can be seen through the search space given below and possibilities are highlighted in blue:

0 – girl, 1 – boy

0000	0001	0010	0011
0100	0101	0110	0111
1000	1001	1010	1011
1100	1101	1110	1111

There are 8 possibilities that 1 is male and 3 are female or 1 is female and 3 are male. They can be younger or elder, youngest or eldest. It is easy to identify possibilities through search space.

Search Space for Nasir's Problem:

Nasir has 8 children. The first 7 babies are boys, what is the probability that the last baby is a boy or girl? In this problem, 0 represent girl and 1 represent boy.

0 – girl, 1 – boy

11111110	11111101	11111011
11110111	11101111	11011111
10111111	01111111	11111111

Here is a comparison of books which are very useful in generating pedagogical content design. It is easy to learn the tools and techniques but are difficult to apply in classroom.

Comparison of national and international books for teaching probability:

Textbook	Punjab	Sindh	Baluchistan	KPK	India	Harvard	O Level
Pages	13	19	7	36	57	20	45
Diagram	1	4	0	19	8	50	45

These are books in which the probability concept is taught at intermediate level. In Punjab textbook, the topic of probability is on 13 pages and there is only 1 diagram. In Sindh Board book, this topic covers 19 pages and has 4 diagrams. In Baluchistan Board, 7 pages and no diagram of this concept. In KPK board, 36 pages and 19 diagrams. This book was far better than others. India's books are accessible online for free on the following link:

National Council of Educational Research and Training

http://www.ncert.nic.in/ India books have 57 pages and 8 diagrams, Harvard had 20 pages and 50 diagrams where O level book has 45 pages and 45 diagrams. It is vitally essential to provide graphical tools to learners while teaching mathematics.

Now here is a detailed description of **Baluchistan Board book** because it has no diagrams so let's critically evaluate it:

One page of this book is totally on exercise.no diagrams, grids or visual tools. One full page is reserved for definitions. Formulas are heavily used.

Punjab textbook:

- Numerous theorems
- No narration
- Heavy use of set notation
- Proofs with heavy notation
- Lacks visual tools

Most commonly, while teaching the concept of probability, following sequence is seen in the books:

- Loads of definitions
- Theorems and Proofs
- Related solved Examples
- Bracketed Exercises

It is important to recognize the concepts hidden in a problem. Therefore, the modern method to teach probability should be:

- Start with an exciting story
- Incrementally introduce new concepts
- Use language, terminology that is known to the learners
- Let students construct knowledge and discover new properties, concepts themselves.
- Provide multiple toolkit
- Facilitate them with pictures, illustrations and other visual tools.
- Do not impose formulae. Instead, have discussions and let them ponder.
- Draw the probability tree and show when multiplication takes place and when addition takes place.
- Do not bracket exercises.

- Approach the problem in different ways and test learners through them to verify their grasp on the topic or concept.
- Draw pictures to enhance creativity. Use appropriate tools to solve problems in a natural way

Salman Khan of Khan Academy makes use of grid, tree and table as search space for solving probability problems. Access the lecture at Khan academy from the following link:

https://www.khanacademy.org/math/probability/independent-dependent-probability/old_prob_videos/v/probability--part-5

Lecture # 15

Topic: “Teaching probability”

Review of previous lesson:

- **What problem can take place in classroom while teaching probability?**
- **How pedagogical content design is generated for probability teaching**

How people learn, bridging research and practice. National Research Council United States- This book recommends how people learn, how to apply the learnt knowledge in classroom, what we actually know about human learning and researches in the past years have proved teaching as an art rather than science. There are many tools and techniques that can be applied in the classroom. One such tool is the prior knowledge of students. Knowledge must be meaningful. Some mental operations and reasoning must be working in the classroom as it is helpful in improving learning. The relationship between what we know and what we are using in practice is essential as well as the feedback on both; which is an ongoing effort than must be continued. The basic concepts in this book are:

- How we learn?
- How we teach?
- What we teach?
- How we assess what we teach?
- What students learn?
- What students do not learn and why is it so?

For example, pre-conceptions or prior knowledge is very important. Students base their learning on misconceptions, if they have any, so, these must be removed.

About teaching of probability, an Israel’s professor recommends that if the problems whose solution is not intuitive are not discussed, they become stronger in minds as misconceptions. A topic can be covered by its breadth and depth. The concept of probability in books of Pakistan text book boards consists of many problems related to probability however, if these are not taught to students in depth they are of no use. Probability is such a topic that even if students do not select mathematics after FSc, they still need to understand the concept of probability e.g. in economics, sociology, weather prediction etc. So, the concept of probability should be taught in depth to the students at all levels.

The book, “How people learn” also recommends that there must be an agenda of research for every country, that could be applied to school, college or university level. It must be comprised of discipline specific experts such as probability expert or chemistry expert, researchers of pedagogy and actual teachers of school or college level. They all must sit together and discuss what are the problems faced while teaching. Such instructional techniques and curriculum design techniques which are related to the rules and regulations of learning that are universally accepted must be reinforced. Those techniques which contradict the learning theories need to be

eliminated. These learning theories and techniques need to be applied in classroom. An expert of the field has the ability to connect the learnt knowledge to solve problems. Whereas a novice or non-expert could not understand how to connect the knowledge with problems. The focus while teaching probability must be on conceptual understanding.

Conceptual Understanding:

Conceptual understanding may be defined as the ability to apply those concepts to future learning of new related material.

It is a responsibility of a teacher to provide such platform to the students so that they can judge their metacognitive skills.

Metacognition:

As the word indicates, it is thinking about the process of thinking. For example, a person thinks about the solution of the problem. But when he is going to apply the solution he is not sure that he is going the right way. He thinks that half the problem can be solved through it but what should be done for the last part? In this way a person is thinking on his own thinking process.

Metacognition is important for:

- Assessment of learning
- Problem solving
- Teaching

Metacognitive skills are as important as cognitive knowledge. For example while teaching the concept of probability; a student has done a mistake while solving a question. Now the teacher instead of correcting it thinks of the reason why student is going wrong. He must assess his prior knowledge and ask him to think in multiple ways to solve that problem. In this way, his misconception about the concept will be addressed and the student will be able to think on his on thinking or solution of the problem. A teacher must provide the students an opportunity to solve the problem and while solving must keep thinking on the process so that there are less chances of errors.

Moreover, every subject has some basic concepts such as in probability, there is addition of probability, multiplication of probability, theorems etc. There are two ways to teach probability, one is that all these concepts must be taught to the students and that will focus on the rote learning or understanding of the concepts. Another way is that to provide them a capacity to use these concepts in real life problem solving. Basic concepts can be understood better if they are presented in the context of real life problems. Here, take an example of Khan Academy's lecture on probability where there is no definition discussed rather it starts with problems in the form of stories. It provides in-depth learning through discussion in the form of stories.

Conference on probability:

In a conference titled: "The probability of understanding probability with or without pedagogy and technology." A questionnaire was circulated among the candidates; all candidates who participated in this tutorial were teaching probability in different colleges or universities.

The International Conference

- **Tutorial: The Probability of Understanding Probability with(out) pedagogy & Technology**
- Name and Affiliation (You may not like to disclose):
- Studied probability

(a) Never (b) in College (c) in University

- Knowledge of Probability

(a) Expert (b) Basic (c) No knowledge

- Ever drawn a probability tree?

(a) Often (b) Rarely (c) Do not remember

After asking these essential questions; some problems were given to them.

Problem No. 1: Yasser has one child. What is the probability that the child is a baby boy? Almost 30 people responded to this question. The options were:

(a) 50%
(b) Less than 50%
(c) Cannot be determined as the data set is too small

Incorrect answers 29/30

Problem No. 2: Yasser has two children – one of them is a boy. What is the probability that the other is a boy?

- 50%
- 33%
- Cannot be determined

Incorrect answers: 29/30

Same was the result for problem: 5

Problem No. 5: Yasser has three children – one of them is a boy. What is the probability that the other two are girls?

- 2/3
- More than 40%
- Cannot be determined

Incorrect Answers: 29/30

If the result of the above questions comes almost 33% correct then it can be a chance. But now it is clear that there is some misconception in the prior knowledge of the participants that is a hindrance in their problem solving.

Lecture 16

Topic: “Effective lecturing”

- “A handbook of Teaching and Learning in Higher Education-Enhancing Academic Practice”
- “Understanding by Design”

These two books focus on ‘How to techniques’ instead of theory. For example, if a teacher is planning for a program or schedule, what guidelines should be followed by her? What are the learning outcomes? How to assess students?

In the first book, “A handbook of Teaching and Learning in Higher Education-Enhancing Academic Practices” the first part is of ‘range of approaches in teaching, learning and supervision.’ In part 2 and 3 discipline specific areas are discussed. For example, practices in Computer science, science, arts and mathematics etc. The book has provided essential information for understanding the complexities of teaching and learning and about their complex relationships.

The book talks about:

- Competing demands in teaching, research and scholarships
- Use of technology in teaching and learning
- How students can be motivated
- Understanding student learning
- Planning teaching and learning
- Learning outcomes
- How to deliver lectures in large groups

An outstanding lecture must comprise of the following aspects; it should be:

- Informative
- Interesting
- Engaging

During lecture ensure that:

- Students are actively involved
- Participation is an active process
- Students are made to think inside the classroom
- Visual aids must be used
- Relate it to their prior knowledge
- Discussion takes place

What special efforts have you taken to engage the prior knowledge of students?

What steps have you taken to keep your students involved and how will you carry out DBL?

How have you planned to address the possible problems of learning?

The pros and cons of using power point in the classroom

In the second book, "Understanding by design- A backward design process" it is stated that:

- Firstly, identify the learning outcomes of your program
- Then identify the learning outcomes of courses in the program
- Then the learning outcomes for mid-term syllabus of the courses etc.
- Teachers must communicate the learning outcomes to the students
- Secondly, ensure that these learning outcomes are fulfilled in the program with the passage of time.
- Identify the methods to verify the learning outcomes
- Thirdly, focus on the method of instruction

Levels of learning outcomes:

1. For some topics, only familiarity is enough
2. The students should be able to know and actually do (they should be able to use those concepts to create something new, OR are able to use those techniques in new situations)
3. Enduring understanding (it is very important to understand some topics, as they seem essential in creating new knowledge)

An experiment on grade 6-7 on teaching of graph theory:

Learning outcomes:

By the end of the course, the students should be able to:

- Start thinking and imagining problems in terms of graphs.
- Represent graphs in data structures
- Discover shortest path algorithms
- Develop a problem solving attitude while using graph as a tool

According to the first book, after learning outcomes, method of instruction must be decided. So, in this experiment conventional teaching method is followed. Lecture method is used in classroom while teaching graph theory. For example, firstly the concept of sets is explained by examples in the classroom. How two sets are multiplied to get ordered pairs. How these are connected to their prior knowledge etc.

If learning outcomes are stated clearly and with the passage of time they are verified and instruction is designed accordingly, then it is quite easy to make student learning in the right way.

Lecture # 17

Topic: The Relationship between Thinking and Learning

- Thinking is Central to Learning.
- Learning is a process that modifies or strengthens world views, beliefs, opinions, attitudes, behaviours, skills, understanding, and knowledge.
- Thinking is a process of response to external stimuli, and if thinking is effective it results in changes to or strengthening of world views, beliefs, opinions, attitudes, behaviours, skills, understanding, and knowledge.
- Thinking and learning have the same outcomes, so have to be very closely related.

We can assume there are basically two types of thinking activity, effective and ineffective.

Ineffective Thinking is where a person makes a determination to think about something, proceeds to do so, goes round in circles, and there is no outcome. The thinking doesn't clarify anything, doesn't raise questions, and causes no change or strengthening to world view, belief, opinion, attitude, behaviour, skill, understanding or knowledge.

Effective Thinking is where there is an outcome. The thinking does make changes to world view, belief, opinion, attitude, behaviour/s, skill/s, understanding/s and knowledge.

If learning results in the same changes we can safely assume that there is no learning without thinking.

- **Thinking is Central to Learning**

Thinking is central to learning because learning is a process where an individual modifies or strengthens world views, beliefs, opinion, attitudes, behaviours, skills, understandings and knowledge.

- There is no learning without thinking.
- The better the thinking, the better the learning.
- The richer and deeper the thinking, the richer and deeper the learning.

If we are serious about empowering our students as learners then we must focus on thinking. Empowering someone as a learner won't happen unless we empower them as thinkers.

A new challenge to schools: Better Thinking equals Better Learning

We now have many schools who are implementing programmes aimed at improving their student's thinking. Many of these schools are also developing assessment processes that show positive outcomes in improved student thinking. The challenge is that if there is improvement in thinking there should also be improvement in learning across the curriculum because learning

and thinking can't be separated. If there is no matching shift in learning then we would have to challenge any data that indicates an improvement in thinking.

Thinking is driven by Questions:

Thinking is not driven by answers but by questions. Had no questions been asked by those who laid the foundation for a field — for example, Physics or Biology — the field would never have been developed in the first place. Furthermore, every field stays alive only to the extent that fresh questions are generated and taken seriously as the driving force in a process of thinking. To think through or rethink anything, one must ask questions that stimulate our thought.

Questions define tasks, express problems and delineate issues. Answers on the other hand, often signal a full stop in thought. Only when an answer generates a further question does thought continue its life as such.

This is why it is true that only students who have questions are really thinking and learning. It is possible to give students an examination on any subject by just asking them to list all of the questions that they have about a subject, including all questions generated by their first list of questions.

That we do not test students by asking them to list questions and explain their significance is again evidence of the privileged status we give to answers isolated from questions. That is, we ask questions only to get thought-stopping answers, not to generate further questions.

Feeding Students Endless Content to Remember

Feeding students endless content to remember (that is, declarative sentences to remember) is akin to repeatedly stepping on the brakes in a vehicle that is, unfortunately, already at rest. Instead, students need questions to turn on their intellectual engines and they need to generate questions from our questions to get their thinking to go somewhere. Thinking is of no use unless it goes somewhere, and again, the questions we ask determine where our thinking goes.

Deep questions drive our thought underneath the surface of things, force us to deal with complexity. Questions of purpose force us to define our task. Questions of information force us to look at our sources of information as well as at the quality of our information.

Dead Questions Reflect Dead Minds:

Unfortunately, most students ask virtually none of these thought-stimulating types of questions. They tend to stick to dead questions like "Is this going to be on the test?", questions that imply the desire not to think. Most teachers in turn are not themselves generators of questions and answers of their own; that is, are not seriously engaged in thinking through or rethinking through their own subjects. Rather, they are purveyors of the questions and answers of others-usually those of a textbook.

We must continually remind ourselves that thinking begins with respect to some content only when questions are generated by both teachers and students. No questions equals no understanding. Superficial questions equal superficial understanding. Most students typically have no questions. They not only sit in silence, their minds are silent as well. Hence, the questions they do have tend to be superficial and ill-informed. This demonstrates that most of the time they are not thinking through the content they are presumed to be learning. This demonstrates that most of the time they are not learning the content they are presumed to be learning.

If we want thinking we must stimulate it with questions that lead students to further questions. We must overcome what previous schooling has done to the thinking of students.

Lecture 18

Topic: Technology in Education

This lecture talks about the tools which are useful in technology. One should talk about technology very carefully, and we can talk about a million dollar technology and very cheap technology. We will touch upon the importance of technology and its effectiveness in classroom learning. Also, we will discuss the recommendations of using present technology in education.

Quotation:

1. “The significant problems that we have created cannot be solved with the same level of thinking we are using when we created them.”
2. “Doing the same thing over and over and again and expecting different results, is insanity.” Einstein
3. If we persist in believing that problems of our schools and colleges can be solved by only improving schools then we will never succeed.

More on the above quotations:

Fundamental transformation argument is given in the above quotations; can technology help in achieving this fundamental transformation among students. How it is possible to achieve and what are the suggestions to improve it.

Following books are referred for this lecture, “Disrupting Class-How disruptive Innovation will change the way the world learns.” by Clayton M. Christensen. And “Innovative University-Changing the DNA of Higher Education from the Inside Out” by Clayton M. Christensen. Another book is “Empowering Students with Technology” By Alan November. And “New Think” By Edward De Bono.

Here is a quotation from the book “New Think” By Edward de Bono, “For a true out of the box thinking, this is a book to read. It actually teaches the *how* of creativity. You can learn to train your mind to be flexible enough to notice the often obscured perfect solution to any problem or situation.”

The above quotation focuses on the lateral thinking, there are several ways of defining lateral thinking, ranging from the technical to the illustrative.

1. "You cannot dig a hole in a different place by digging the same hole deeper"

This means that trying harder in the same direction may not be as useful as changing direction. Effort in the same direction (approach) will not necessarily succeed.

2. "Lateral Thinking is for changing concepts and perceptions"

With logic you start out with certain ingredients just as in playing chess you start out with given pieces. But what are those pieces? In most real life situations the pieces are not given, we just assume they are there. We assume certain perceptions, certain concepts and certain boundaries. Lateral thinking is concerned not with playing with the existing pieces but with seeking to change those very pieces. Lateral thinking is concerned with the perception part of thinking. This is where we organize the external world into the pieces we can then 'process'.

3. "The brain as a self-organizing information system forms asymmetric patterns. In such systems there is a mathematical need for moving across patterns. The tools and processes of lateral thinking are designed to achieve such 'lateral' movement. The tools are based on an understanding of self-organizing information systems."

This is a technical definition which depends on an understanding of self-organizing information systems.

4. "In any self-organizing system there is a need to escape from a local optimum in order to move towards a more global optimum. The techniques of lateral thinking, such as provocation, are designed to help that change."

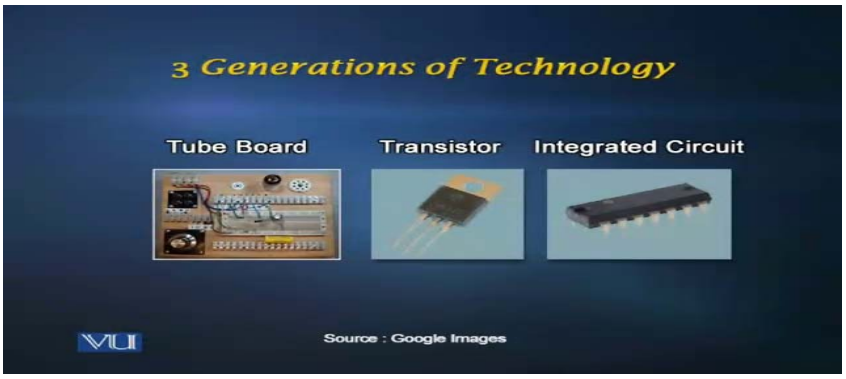
This is another technical definition. It is important because it also defines the mathematical need for creativity.

According to Clayton, schools in America have employed technology in perfectly predictable, perfectly illogical and perfectly wrong ways.

Technology can be disruptive.

Disruption has some very interesting properties. Existing technology has very higher level whereas disruptive technology is of lower level which never meets with the higher technology. This is mostly popular in non-consumers. (Non-consumers are the people who could not afford the higher technology.)

There are three generations of technology:



People keenly used to listen to the transistors. Because at that time people could not afford the expensive technology. So disruptive technology was in use.

“The Soul of a New Machine” By Tracy Kidder, gives the detailed description of the micro-computers designed in the late 1970s and 1980s.

There was a Data General Corporation that built a mini computer which was better than the machines made by IBM and Digital Corporation. Image is given below:

Expertise needs ten thousand hours of practice. Data General Computer was built by Tom West.

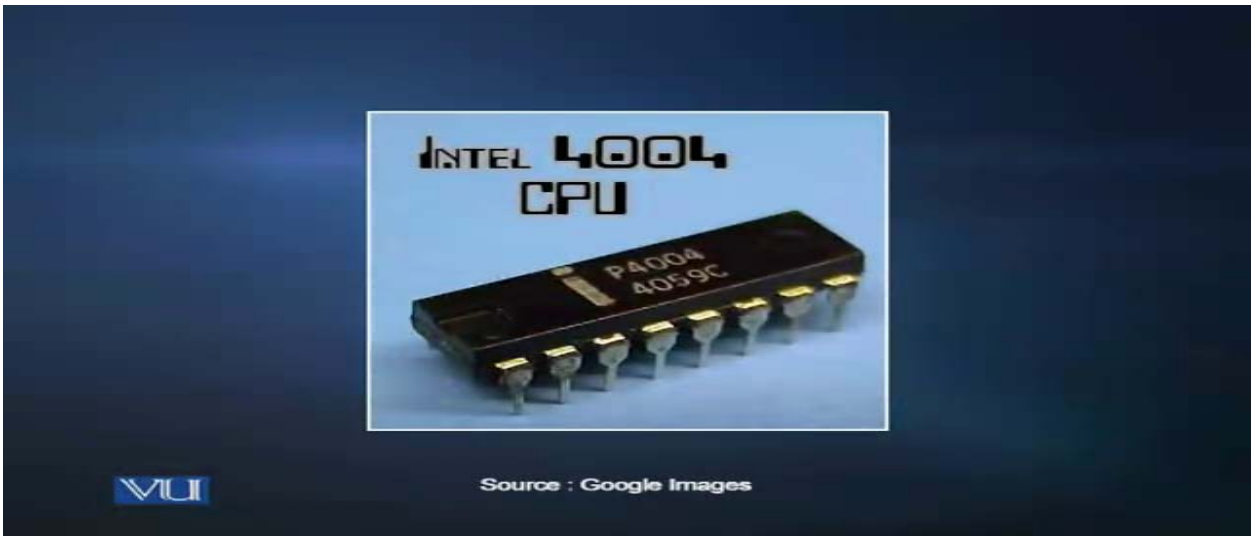
Another technology:

The people who went abroad for study in 1980s were proud to use VAX 780. I t costs 120,000 dollars. It was very clean and systematic.

Computers can be very addictive.

Here are some other computers:

All the disruption in the technology started from the computer image given below:



How these computers were started in market:

A company requested Intel to design a micro processor for them. Intel determined it was too complex and would use non standard packaging and so it was proposed that a new design produced with a standard 16-pin DIP packaging and reduced instruction set be developed. This

resulted in the 4004 which is a part of a family of chips including ROM…the 4004 was built with 2,300 transistors. It was followed by 4040 and 8080.

In 1969, Nippon Calculating Machine Corporation requested that Intel design 12 custom chips for its new Busicom 141-PF printing calculator. Instead of creating a dozen custom chips specifically for the calculator, Intel’s engineers proposed a new design: a family of just four chips, including one that could be programmed for use in a variety of products. The story of disruption in computers began from here.

Three companies were very famous at that time who worked very fast in this field:

1. Commodore (Canadian company)
2. Apple (Steve Jobs company)
3. RadioShack (Tendi corporation)

The commodore 64 has frequently been compared to Fort Model T. It was the first cheap computer for the masses. The commodore 64 features 64 kb of RAM and 1MHz chip and looks like nothing more than just a bulky keyboard.

According to the Guinness Book of World Records, the commodore 64 is the best-selling computer of all times. About 30 million were sold between its launch in 1982 and its commercial decline in 1993.

Here is the image and information about Commodore pet machine:

Quotation from Daily Times:

“Picasso had a saying that good artists copy, while great artists steal. We have always been shameless about stealing great ideas. I think part of what made the Macintosh great, was that the people working on it were musicians, poets, artists, zoologists, and historians who all happened to be the best computer scientists in the world.” Steve Jobs, The Daily Times.

Lecture # 19

Topic: Addressing problems of learning through technology

Disruptive technology:

Disruptive technology is a term coined by Harvard Business School professor Clayton M. Christensen to describe a new technology that unexpectedly displaces an established technology.

In his 1997 best-selling book, "The Innovator's Dilemma," Christensen separates new technology into two categories: sustaining and disruptive. Sustaining technology relies on incremental improvements to an already established technology. Disruptive technology lacks refinement, often has performance problems because it is new, appeals to a limited audience, and may not yet have a proven practical application. (Such was the case with Alexander Graham Bell's "electrical speech machine," which we now call the telephone.)

A recent report from the McKinsey Global Institute titled "Disruptive technologies: Advances that will transform life, business and the global economy," set out to identify technologies that will have "massive, economically disruptive impact between now and 2025."Of the 12 technologies selected, which includes advanced robotics, next-gen genomics, and energy storage; McKinsey states that the mobile Internet will bring the most disruption.

In his book, Christensen points out that large corporation are designed to work with sustaining technologies. They excel at knowing their market, staying close to their customers, and having a mechanism in place to develop existing technology. Conversely, they have trouble capitalizing on the potential efficiencies, cost-savings, or new marketing opportunities created by low-margin disruptive technologies. Using real-world examples to illustrate his point, Christensen demonstrates how it is not unusual for a big corporation to dismiss the value of a disruptive technology because it does not reinforce current company goals, only to be blindsided as the technology matures, gains a larger audience and market-share and threatens the status quo.

Technology is disruptive. In E-commerce, Amazon has provided you the opportunity to buy and sell books. At start, internet telephone calling was of very low quality, but with the passage of time it has been improved. Mobile phones today are said to be the technology for teenagers because it has a micro computer in it. So, mobiles phone internet will bring most disruption.

Lecture # 20

Topic: “Power of visualization”

Power of visualization among adults:

If an apple is placed in front of the students, they will think about it according to their prior knowledge. Firstly, it is related to Newton laws because Newton gave the law of gravitation after he observed while he was sitting under a tree and an apple fall on his head. Secondly, apple is also associated with teachers.

The apple is a symbol for teachers and teaching — students have given shiny fresh apples to their teachers on the first day of school for over a century. But exactly how the apple earned this distinction is not entirely clear. The most common explanation is that in the 16th through 18th centuries in Denmark, Sweden, and the United States, poorer farming folk would pay their children's teachers with food - most notably with common and plentiful apples and potatoes. Another is that farmers gave teachers this food to supplement the teachers' low incomes; as teachers' wages went up, the amount of food went down. Eventually, students brought in that one apple out of tradition more than anything else.

Why Does the Apple Symbolize Teachers?

The apple has been associated with knowledge ever since Adam and Eve ate from the Tree of Knowledge. More recently, apples have come to symbolize teachers because poor students would give apples to teachers as payment.

‘Imagery is a powerful force for perception and understanding. Being able to “see” something mentally is a common metaphor for understanding it. An image may be of some geometrical shape, or of a graph or diagram, or it may be some set of symbols or some procedure.’

(Open University, 1988, p. 10)

- Visual system has a modelling power
- Visual system is a powerful tool for long term memory.

When you write word ‘apple’ in google, most searches are of apple iphone instead of teacher apple.

Steve Jobs (1955-2011) was once asked by the author who was writing his biography that if you could get more life, what would be your wish to fullfil? Steve replied that he wants to work on technology in education. Similarly, we can teach the students through technology today and can address their problems.

In the book, “Making Thinking Visible- How to Promote Engagement, Understanding and Independence for All Learners.” By Ron Richart and Mark Church writes that try to focus on the

power of visualization of students. Thinking is something abstract. It was ask from the adults that what is thinking? Whenever we talk about thinking, what is visualizing in your mind?

Views of different students on thinking are:

- Whatever you are thinking you must ask questions about that to yourself.
- Thinking is storing things in different sections of mind.
- I compare things to what I know about it.
- I always look around where I am and get some good ideas. I always have a mental picture in my head when I am thinking.

Some teachers assume that students know some concepts already. Teachers do not focus on their prior knowledge. For example, if a teacher is going to teach periodic table in class. It is important to understand atomic structure before understanding and discovering periodic table. If the students do not know about the atomic structures, they will never understand periodic table. So,

- Keep testing and challenging your assumptions about the prior knowledge of the students.
- New knowledge is built on the basis of prior knowledge.
- Meaningful learning should be coupled with meaningful assessment.

For example, observe a classroom of 9^{th} grade or O’levels. Where a teacher is goin to teach students the concept of kinematics. Howard Calculus has suggested four major points to teach a concept:

- Firstly, start the lesson with a story, which includes the linguistic part of these points or description. (verbally)
- Secondly, we got some data on the basis of the story. So a table can be generated on how much distance is travelled after 10 mins, 20 mins and so on.
- Thirdly, we can make a graph of it. i.e. a graph of displacement of a vehicle which is going from Lahore to Islamabad. Or a child riding a bicycle.
- The last aspect is analytical in which we try to model the graph in the form of equations.

It is very important to connect these four aspects. In short, these four rules of Harvard Calculas are, that every concept should be presented:

- Graphically
- Symbolically
- Numerically
- Verbally

In order to check the problems faced by students in classroom settings, a survey was conducted in a very well known school at Lahore.

Meaningful learning should be coupled with meaningful assessment.

A problem was proposed to the students. i.e.

A girl Komal is going to her grandmother's home on a bicycle. The distance can be covered in almost 100 minutes. When Komal starts traveling, she is riding her bicycle on a constant speed, on a straight line so the distance and displacement are the same. She reached a park at the constant speed. She spends 30 mins in the park and then goes to her grandmother's home but on a different constant speed. There is a speedometer on her bicycle which tells her the speed and distance covered from her home to her grandmother's home. We present the students with the following data which shows the distance covered after every 10 mins:

Time (minutes)	0	10	20	30	40	50	60	70	80	90	100
Distance covered (km)	0	-	3	-	-	8	-	-	8	-	16

The following questions were asked from the students:

1. What is the distance of grandmother's home from Komal's home?
2. At what time, Komal arrived at the park?

Students faced many problems in it because there is no graph given in this problem. There is only a story and some readings. Students are asked to fill the table by writing other readings of the speedometer.

The skill of problem solving using mathematics is necessary because if students do not experience this skill then they can never solve problems in real world. It is assumes that, students know the basic mathematics taught at grade 6-7 or they can experience such problems by facing trial and error. Calculation must be taught to the students but the fact is technology has advanced in the last decades. Calculators are most commonly used device for calculations. Calculation part in mathematics is not that important now but to relate logic to narrative part of problem solving must be focused.

The students after receiving the question papers asked that is that an exam of mathematics or English? Because a story is being tell about Komal. Secondly, the goal in the questions is not clear. The main question in this story is to identify the time when Komal was in the park. What were those 30 minutes she spends in the park? The students have to logically think and do deductive thinking on how to get the information to achieve the goal of the problem. Then the students were asked to draw a graph of this problem. Students were divided in to three groups. First group was asked to draw the axis of the graph and scale it. Second group is given the drawn axis and asked to write its scale. While third group was given axis and scale. So now the problem

becomes easy to solve for the students of third group. The next problem the students faced was to place the points of the table in the graph. The basic problems were:

- To think of visualization from a story
- To think of graphs from numeric form/table values.

To facilitate students in these problems, a teacher must:

- Represent concepts in multiple forms

Important factors for success in future:

- Innovation (to create something new)
- Communication (You are not working alone, you have to communicate and share with the people)
- Collaboration
- Problem solving

Lecture # 21

Topic: “Jigsaw Learning”

Assume that you entered a classroom of Grade 9th or 10th; I want them to see some pictures. Then I will divide them into groups and ask them to choose any two pictures and try to build a connection between them. It is basically an art to develop a connection between two concepts or points. It is a part of knowledge creation. It is the ability to search your own database in a creative and new way. Many different thinking are involved in this activity, firstly one has to think about the prior imaginations in mind. The he has to visualize both the images and its connections; thirdly, he needs to think whether these imaginations are right or wrong?

Important things in such activity are:

- Think aloud/conversation
- Imagination
- Visual imagination is a very powerful tool to understand the concept
- Try to make a story which connects all the images and concepts in one link.

The Jigsaw Method:

The Jigsaw method is a cooperative learning technique in which students work in small groups. Jigsaw can be used in a variety of ways for a variety of goals, but it is primarily used for the acquisition and presentation of new material, review, or informed debate. In this method, each group member is assigned to become an "expert" on some aspect of a unit of study. After reading about their area of expertise, the experts from different groups meet to discuss their topic, and then return to their groups and take turns teaching their topics to their group mates.

Benefits of the jigsaw technique:

- Students are directly engaged with the material, instead of having material presented to them, which fosters depth of understanding.
- Students gain practice in self-teaching, which is one of the most valuable skills we can help them learn.
- Students gain practice in peer teaching, which requires them to understand the material at a deeper level than students typically do when simply asked to produce on an exam.
- During a jigsaw, students speak the language of the discipline and become more fluent in the use of discipline-based terminology.
- Each student develops an expertise and has something important to contribute to the group.
- Each student also has a chance to contribute meaningfully to a discussion, something that is more difficult to achieve in large-group discussion.
- The group task that follows individual peer teaching promotes discussion, problem-solving, and learning.

- Jigsaw encourages cooperation and active learning and promotes valuing all students' contributions.
- Jigsaw can be an efficient cooperative learning strategy. Although the jigsaw assignment takes time in class, the instructor does not need to spend as much time lecturing about the topic. If planned well, the overall time commitment to using the jigsaw technique during class can be comparable to lecturing about a topic.

Lecture # 22

Topic: “Importance of asking questions”

In the "curious classroom," carefully crafted questions, generated by both teachers and students, enhance student learning. Sometimes teachers also do not know the answer to questions, students ask. The relevant answer to the question is not that important in fact, asking the right question is the fundamental to the process of learning. The psychological state of asking questions in classroom is said to be problem solving. Because sometimes, a teacher don’t know how to find the answer to the question, where to find it or if found, then how to convey it effectively to the students? Problem solving is the best way to find answers to questions. After finding the relevant answers, verify it logically.

A survey was conducted in which the students of LUMS, NUST, FC College, and Virtual University of Pakistan were interviewed. Some very basic questions were asked about day and night and seasons. But unfortunately 98% of the respondents were unable to answer properly. They do not have the basic knowledge of why day, night or seasons occur? So, there is a flaw in our teaching and learning methods. Students know the answer to the questions but they do not know the logic behind its being correct. The way to test it is by hypothesis testing. Knowledge gained must be linked with hypothesis testing. When a problem is proposed to the students, they visualize it and list down the possible answers, and then they must be taught to think critically on every answer. They must think like, is the answer correct? If yes, why? If not, why? Going through this process, their knowledge base will become rich. If students only learns or memorize the answers, their base of knowledge is never rich. Teachers usually avoid hypothesis testing in classroom because it is time consuming. Today, internet can provide answers to many questions and solutions to problems in a limited time. But internet cannot provide us with hypothesis testing. So, teachers must focus more on the hypothesis testing instead of recommending internet search to the students. While hypothesis testing, the best state to learn is **creative tension.** Creative tension is a situation where disagreement or discord ultimately gives rise to better ideas or outcomes. A teacher must make an effective learning environment in classroom and at last must have control over it. Because confusions in classroom is according to the thinking of the students as all students think differently.

For more on asking questions please see:

http://oer.educ.cam.ac.uk/wiki/Teaching_Approaches/Questioning

Lecture # 23

Topic: “Importance of asking questions”

In the book, “Make Just One Change- Teach Students to Ask Their Own Questions” By Dan Nothstein and Luz Santana wrote that, if students got the capacity of asking quality questions, then the main purpose of education is fulfilled. There is no such procedure to teach students about how to ask quality questions. Whereas, teachers can guide the students in gaining right answers to the questions.

Diverse ability to think in diverse situations should be developed among students from school level. In any seminar, a presenter presents something and at the end questions are asked. The presenter allows the audience to ask questions. If the audience does not ask questions, it is assumed that they agree with all the words of the speaker. Whereas if questions are not asked at the end of any class or seminar, it means that the audience did not understand or they disagree with you to the extent that they could not argument with you. If there are no questions in any seminar, classroom, discussion, business meeting etc. then it seems that things are as bad as it can be. If a presenter presents his/her point effectively to the audience and he is able to change their thinking, then questioning at the end is evidence of it.

Sometimes students feel that their prior knowledge contradicts with their new knowledge. It is possible that their prior knowledge is confusing or the way they are trying to interpret it is wrong. Unless students do not reconcile with it, they cannot proceed further in gaining new knowledge. It is a big challenge for teachers that confusion among students in knowledge must be manageable to be productive. Manageable productive confusion is very effective tool for good classroom.

In the book, “Making Thinking Visible- How to Promote Engagement, Understanding and Independence for All Learners” By Ron Richart and Mark Church. It is written that:

- “There is a worldwide movement effort to make the development of the intellect a priority for education in the 21st century. This book will become a landmark in that journey”
- “Making thinking visible” is an essential reading for every educator who strives to provide students with the skills they need to become thoughtful and enthusiastic directors of their own learning.
- When thinking is made visible, then learning is inevitable. “Making Thinking Visible” invites the reader to craft the new definition of education and presents a dramatic leap forward for education.

More on the above points:

It is very important to know what a child visualizes in his mind. Imagination power of children is very strong as compared to the young ones. As long as we study in college or university, our capacity of asking questions and visualizing them decreases. The capacity of asking questions and visualization are interlinked with one another. For example, when a teacher tries to visualize something to children, they have the inherent capability to visualize; a strong power of visualization, how the child share his visualization with other people is said to be his creativity.

A teacher must:

- Identify key elements which should be communicated dents and then devise a pedagogical strategy to convey them.
- Make concept maps while teaching. Reflect on them whether they are effectively imparted to the students or not?
- Concept maps are not only important as a learning tool but they also play a vital role as an assessment instrument.
- Teacher must teach the students through hypothesis testing

Hypothesis testing:

Hypothesis tests are procedures for making rational decisions about the reality of effects. A problem can have multivariable solutions. But there is a dominant answer to every question.

Lecture # 24

Topic: “Pedagogical strategies and technology in classroom”

Quotation:

“Science does not purvey absolute truth. Science is a mechanism. It is a way of trying to improve your knowledge of nature. It is a system of testing your thoughts against the universe and seeing whether they match.”

Isaac Asimov

More on the above quotation:

By using technology, people can be provided with the platform where they can test their knowledge and observe if their misconceptions are contradictory. Can a student test his hypothesis on the basis of daily life questions? If the purpose of hypothesis testing is not accomplished then our education is useless.

A born child is always very creative in mind. The book, “Out of Our Minds-Learning to Be Creative” by Ken Robinson, It is written that, one can learn creativity and enhance the power of capability.

“There is a paradox: as children most of us think we are highly creative. As adults many of us think we are not. What changes as children grow up? Organizations across the world are competing in a whirl that is changing faster than ever. They say they need people who can think creatively, who are flexible and quick to adapt.”

Too often organizations say they cannot find creative people. Why not? That is the basic question. In this provocative and inspiring book, Ken Robinson addresses these three vital questions:

1. Why it is essential to promote creativity?
2. What is the problem? Why do so many people think they are not creative?
3. Young children are buzzing with ideas. What happen as we grow up and go through school to make us think we are not creative? What can be done about it?

If a student is a slow learner, a teacher must provide him with a choice to learn on his own pace. All students cannot learn at the same level of understanding. Secondly, immediate feedback must be given to the students. Unless a student does not try to do a conscious effort to erase the deepen misconceptions in his mind. Through the use of technology, teachers can bring students to the same level of learning. In short,

- Let students learn at their own pace.
- Let them get intermediate feedback to realize their misconceptions and wrong connections between different concepts.

Pedagogical strategies should be developed that allow:

- Individual learning pace
- Instant feedback
- Excitement, wonder and enjoyment of students in classroom.

Lecture # 25

Topic: “Commandments for teachers for an effective classroom”

When a teacher enters a classroom, he must create a learning environment where students learn by interest, enjoyment and wonder. But unfortunately, today most teachers deliver the lecture in such a way that lacks student interest. Talent of the students is destroyed.

Two equations were given to the students to solve, which are:

$Y= -2x + 7$

$Y = -4x + 11$

It was mentioned to the students that firstly, they have to make table of these equation, secondly, plot them in the graph and then solve to get the answer. Point of intersection is to be calculated. The following instructions were given to them:

1. Think what would be the major obstacles of learning to solve the given problem?
2. What pedagogy would you use to address the above mentioned problems of learning?
3. What specific features of power point 2010 would you use to support the pedagogy to address the problems of learning?

Student must try to find answers through hypothesis testing. **Hypothesis tests** are procedures for making rational decisions about the reality of effects. Secondly, students are able to do problem solving. For problem solving, they need to develop a hypothesis to get answer to the question. Hypothesis testing and problem solving go side by side. When a problem is proposed to the students, they think of a possible answer, but at the same time if their mind is stuck with another daily life observation that contradict with the answer, now here the thinking process starts that proceeds with problem solving and hypothesis testing.

There is a need to develop thinking process in the minds of students today. Thinking process among students can never be developed by proving the students with:

- Air conditioned classrooms
- Beautiful architecture
- Fashionable teacher
- Computing lab

Second issue in Pakistani schools today is that teachers come to the classroom delivers a lecture conventionally. There is no collaboration among students in classroom. Designing a collaborative classroom is very hard for teachers. It is assumed that whatever a teacher speaks in classroom is understood by the students. Such lectures are never interactive, which means that students forget the previously learnt material after sometime and as a result they are not able to understand a new concept. In classroom learning environment,

- the first thing is that we must measure what students have learnt today in classroom and are they able to relate this information with the previous one to solve problems.
- If teachers are not available in classroom, students must be involved in learning activities.
- When homework is assigned to the students, it must be kept in mind that will the students be able to complete their homework on the basis of the concepts learnt today in the classroom.
- All the above three steps are integrated, how effectively he completed his homework. What mistakes are dome by him while doing his homework are all associated with the learning in classroom.

10 Commandments for Teachers by Bertrand Russell:

1. Do not feel absolutely certain of anything (means learn to tolerate ambiguity, learn to have open mind about all questions)
2. Do not think it worthwhile to proceed by concealing evidence, for the evidence is sure to come to light.
3. Never try to discourage thinking for you are sure to succeed.
4. When you meet with opposition, even if it should be from your husband or your children, endeavor to overcome it by argument and not by authority, for a victory dependent upon authority is unreal and illusory.
5. Have no respect for the authority of others, for there are always contemporary authorities to be found.
6. Do not use power to suppress opinions you think pernicious, for if you do the opinions will suppress you.
7. Do not fear to be eccentric in opinion, for every opinion now accepted was once eccentric.
8. Find more pleasure in intelligent dissent than in passive agreement, for, if you value intelligence as you should, the former implies a deeper agreement than the latter.
9. Be scrupulously truthful, even if the truth is inconvenient, for it is for more inconvenient when you try and conceal it.
10. Do not feel envious of the happiness of those who live in a fool’s paradise, for only a fool will think that it is happiness.

Lecture # 26

Topic: "Posing problems with a context"

Two equations were given to the students to solve, which were:

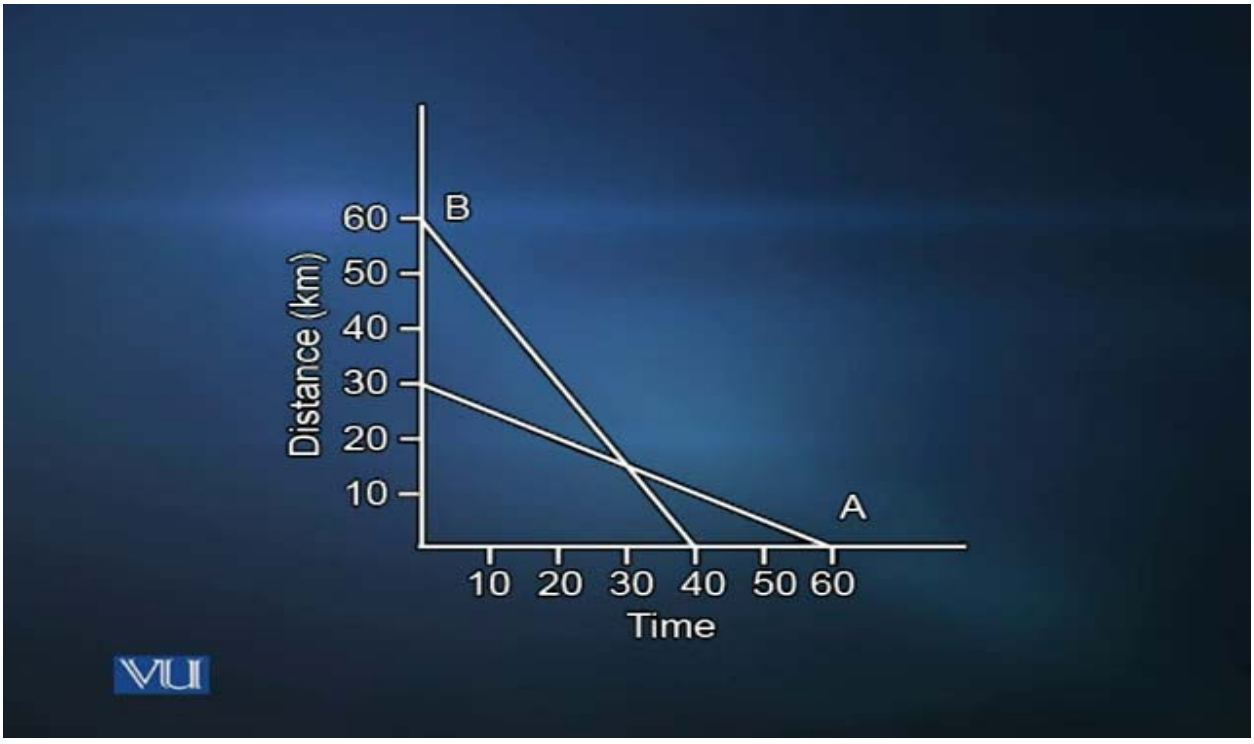
Y= -2x + 7

Y = -4x + 11

It was mentioned to the students that firstly, they have to make table of these equation, secondly, plot them in the graph and then solve to get the answer. Point of intersection was to be calculated. The following instructions were given to them:

1. Think what would be the major obstacles of learning to solve the given problem?
2. What pedagogy would you use to address the above mentioned problems of learning?
3. What specific features of power point 2010 would you use to support the pedagogy to address the problems of learning?

If value of X is given to the students, are they able to calculate the value of Y? If the same problem is proposed to the students in some context, then it will become easy and more understandable to the students. If the graph of the equation is presented as:

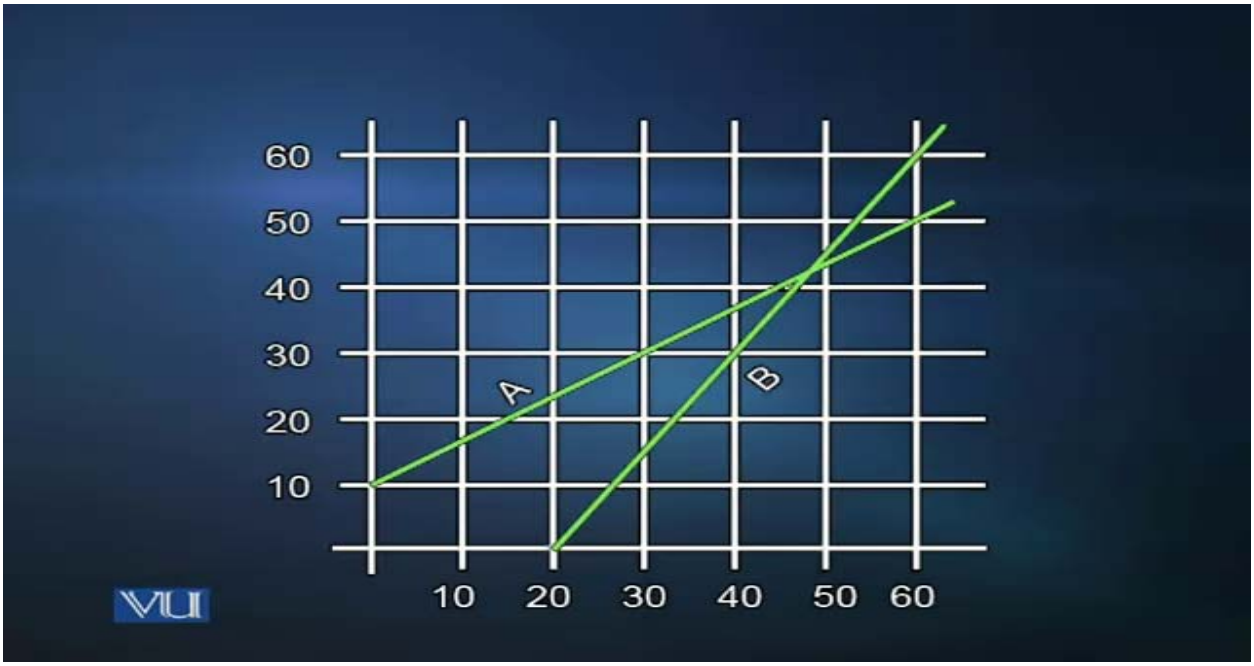


On X-axis, the values show time and Y-axis shows Distance. Now the equations will be solved on the basis of 'in how much time, how much distance is covered?' The graph is formed on the basis of these equations. Now the point of intersection is to be found. It will be easier if you try to make a story behind these equations. For example,

Two cars are travelling to Lahore, one has the distance of 300km and the other has 600km. One is travelling at more speed than the other. Is it possible that these two cars will cross each other at a certain point? Or there is a common station where they can meet each other.

Example 2:

Here is another graph for simultaneous equations:



Now here, 2 cars A and B are travelling to Lahore in which car A travels from 10 km to Lahore while Car B starts from 20 km to Lahore. Car A is at a constant speed and starts to travel first. While car B travels 20 minutes after that. Is it possible that the second car (car B) which starts travelling after 20 minutes and has more speed reaches the destination first? Now such story telling can create motivation among students. They will think that a fast moving car will reach the destination first; can both the cars intersect or cross each other at a certain point? If a certain point is decided to meet, what should be the speed of the car to meet the people in other car on time? In this problem, it is assumed that the speed of cars is constant; if variation in speed of the cars is also added then this problem can become more interesting for students.

It is important to provide the students with context of a story while teaching simultaneous equations because it creates meaningfulness to the students. They will understand the concept more clearly when associated with daily life situations.

Teachers in classroom must discuss with the students what they are going to learn. It is the responsibility of a teacher to create an effective learning environment in the classroom. The teacher must focus on:

- Creativity
- Critical thinking
- Communication
- Collaboration

We need to provide the students with daily life experiences for learning, so that they can be involved both physically and emotionally in learning. Problems in real life do not have a black and white solution. Teachers must also keep in mind that different students have different levels of learning. Such type of teaching and learning process follows **4C Model.** In this model following should be taken into account:

- **Context:** Present a real life story, problem or scenario in a context
- **Challenge:** Incrementally, make the problem a challenge.
- **Choices:** Let the students explore the choices that they have.
- **Consequences:** Allow students to think critically about the consequences of adopting each choice.

In short, a teacher must take into account the following:

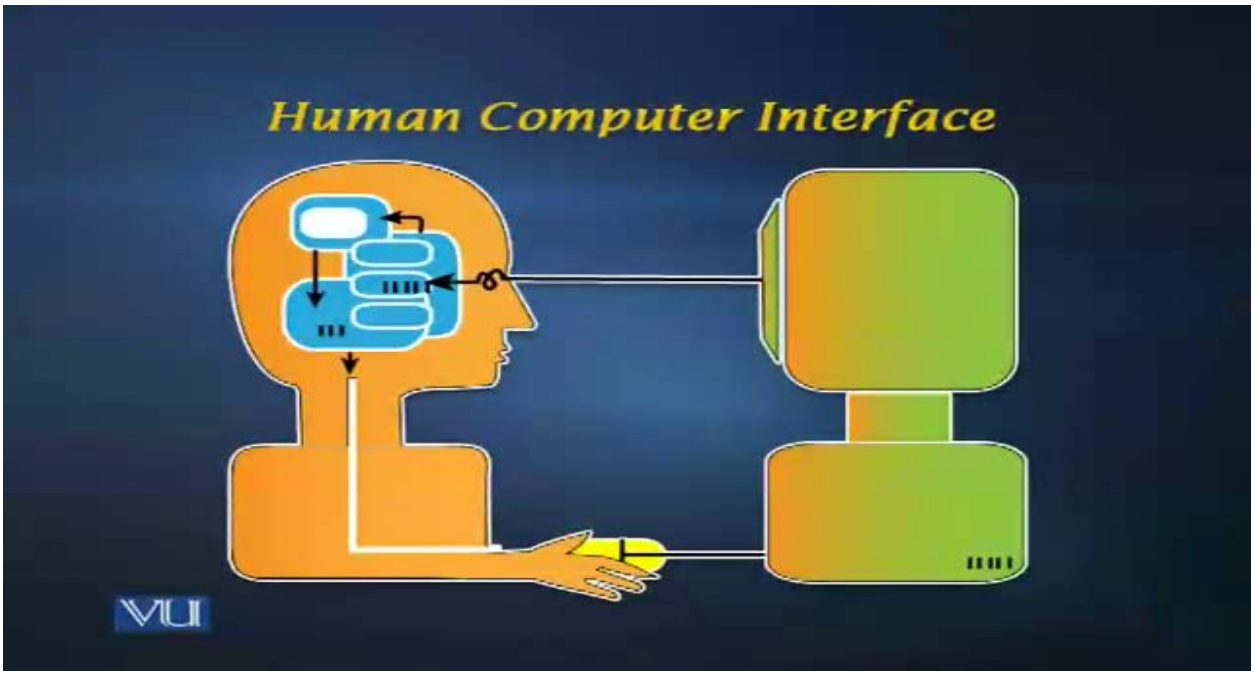
- Critical thinking
- Context
- Challenge
- Choices
- Individual Pace of Learning
- Instant Feedback: Rapid and frequent feedback helps students achieve their learning goals.

Lecture # 27

Topic: "Human Computer Interface"

When a teacher enters a classroom, he knows what he has to teach today, how to teach, how to assess the prior knowledge, of students and students' reaction is the feedback that he gets immediately from the students. This feedback can be made more effective by using technology in classroom. The process of feedback must be continuous that is feedback must be taken from the students after every 10-15 minutes. Whenever the students give an answer, a teacher tries to analyze whether the students are thinking in the right direction to solve a problem or not. A teacher can trace the thinking process and precede it in the right direction if needed. When a teacher poses a problem there are many choices of right answers, and there are consequences on the basis of every choice. After the discussion of these consequences, the choices of answers get limited.

While interacting with technology, it is not necessary that your teacher is always available to you as is the case in conventional teaching. Computer allows you to make many choices and on the basis of these choices you yourself choose consequences. You can make choices of your teacher's availability as you interact with the computer and the interface that you interact with is called **Human Computer Interface.**

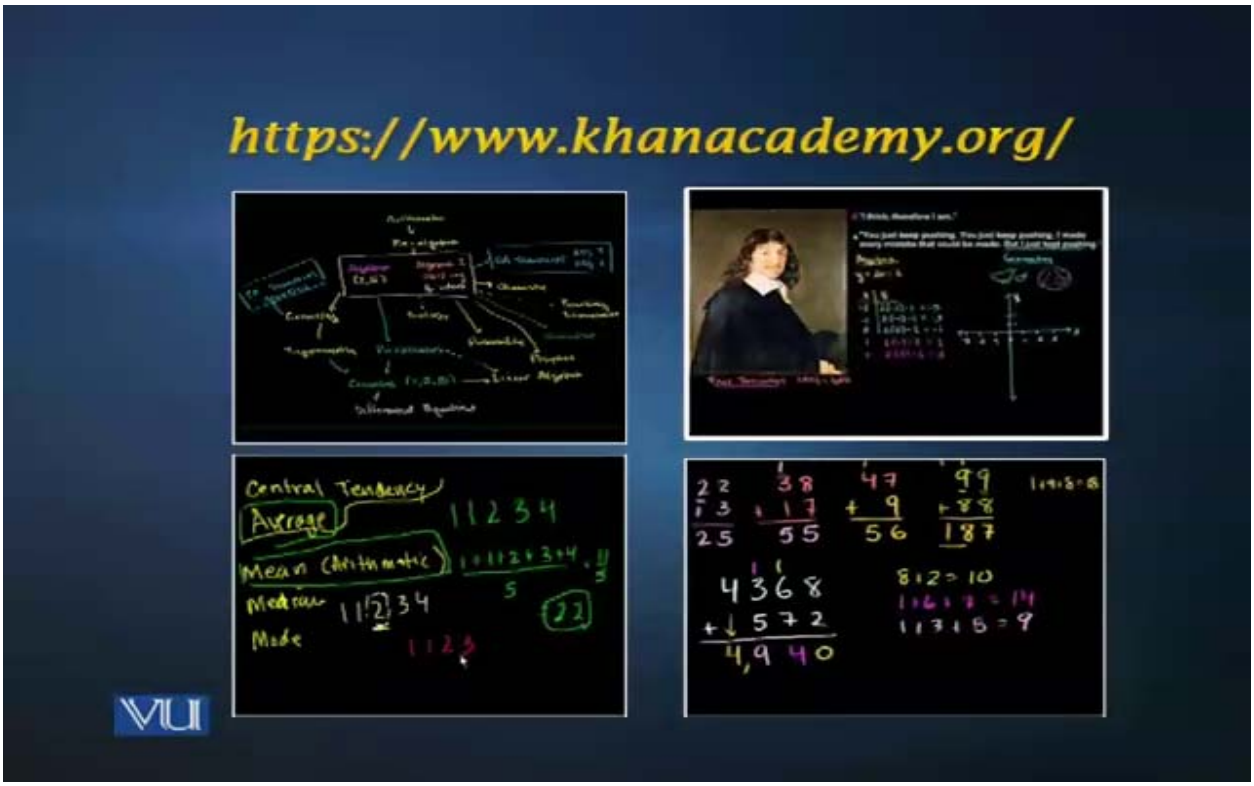


Human Computer Interface:

Human Computer Interface is now being used as a **Learning Interface.** Human Computer Interface was first used in web page design by different marketing companies for buying or selling. But when we use HCI in learning, its purpose is to challenge them to make choices based

on what they have learnt. When choices are made, then how the computer responds to the choices is basically the function of HCI.

For example, the interface of Khan Academy is also a web based learning portal. Its interface is not attractive as shown in the image below:



If you visit the separate window for examinations on khan academy, it is interactive whereas the videos of Khan Academy are not interactive at all. The interface is designed to augment the learning process.

Definition of Human Computer Interface (HCI):

HCI (human-computer interaction) is the study of how people interact with computers and to what extent computers are or are not developed for successful interaction with human beings. A significant number of major corporations and academic institutions now study HCI. Historically and with some exceptions, computer system developers did not pay attention to computer ease-of-use. Many computer users today would argue that computer makers are still not paying enough attention to making their products "user-friendly." However, computer system developers might argue that computers are extremely complex products to design and make and that the demand for the services that computers can provide has always outdriven the demand for ease-of-use.

One important HCI factor is that different users form different conceptions or mental models about their interactions and they have different ways of learning and keeping knowledge and skills (different "cognitive styles" as in, for example, "left-brained" and "right-brained" people). Another consideration in studying or designing HCI is that user interface technology changes rapidly, offering new interaction possibilities to which previous research findings may not apply. Finally, user preferences change as they gradually master new interfaces.

Advantages of HCI:

- Very flexible with the use of “switches” (options)
- Good for “expert” users - can quickly access commands
- Uses the fewest system resources

Disadvantages of HCI:

- Requires the user to learn “complex” commands or language
- “Hidden” features i.e. if you don’t know the commands you won’t know the features are there
- Not very good for novice users

HCI must be introduced as a separate subject at University level so that computer engineers can use the interface internationally as well. HCI as a subject is a critical concept because many Universities like Stanford, Harvard, Cambridge, Oxford etc. offer HCI as a compulsory subject in their CS degree programs. It is focused on the quality of product. There is a misconception among people about HCI and they believe that its front interface must be attractive. However, the functions and specifications of the software are more important. Where ever there is interaction of humans with machines, it needs to be enhanced in many ways. If I look at the products produced according HCI interface then it can be: Samsung Galaxy Tab and IPad

If these two are compared, first thing is that their weight is very low. Pointer speed of screen is different then other products. These differences can add on to the usability of the product beyond the colors or front interface. Because if the weight of the hardware is heavy then it does not feel right in your hand at all. All of this is linked to the human psychology of how people will

perceive it. If people perceive that it is easy to use then it can be used to enhance learning as well after some time of experience.

HCI merges the following three areas:

- Psychology
- Computer Science
- Virtual Design

Basic HCI Heuristics:

- Rate of responsiveness
- Error recognition and communication
- Interface feedback

Lecture # 28

Topic: Technology in Learning

The first thing that most students do in classroom is listening and watching around the things in classroom whether it is a conventional classroom, e learning or blended classroom. It is very unfair with the students if teachers believe that students will start reading without looking at the book or without thinking.

Another important activity that students engage in classroom is discussion. The students must think and explain with one another just as they do in collaborative learning. Collaborative learning plays an important part in e learning and peer interaction. Peer interaction means that if teacher gets feedback from the students and comes to know of any difficulty in student understanding then he can make groups and start peer interaction. Students will learn the concept better by discussion instead of listening the same thing by the teacher again.

Third step is instant feedback. Because of instant feedback, all the weaknesses are highlighted and gradually can be overcome through proper planning.

Importance of learning in classroom:

The major thing in classroom learning is that teachers must think they are teaching a particular concept. why and how to teach it in classroom? These two factors are very important for a teacher because what a teacher wants to teach is the expertise he already has. Due to this expertise, he can impart knowledge to his students very effectively and efficiently. If a teacher is successful in gaining students interest in classroom, then the knowledge goes from short term memory to long term memory of the students. Students learn best through visualization. If a biology teacher wants to teach about fish, then with the help of technology he can show a live fish in the jar on the projector so that all students can visualize it. While showing them the live fish he can explain the parts and properties of it instead of reading about it in the textbook. A teacher has to be an artist if he wants his students to learn something permanently or wants the knowledge to get stored in long term memory.

Advancement in technology in the last 15 years:

An experienced UET professor Shahid Bukhari has shared that he is the legend of teaching. He utilized almost all the resources provided by the University in his teaching. Firstly, he was against piracy. In 1994, he developed a laboratory on Linux, this was interconnected through internet. Amazingly, this became State of the Art laboratory in UET. He showed a lecture on his screen and the same was displayed to the students as well on their screens. It was a very low cost technology. All the students viewed the assignment on their screens and started working independently. He always tried to create a story in teaching and in this way he practically transformed his lecture. In order to get feedback he divides the students in groups. Students were

given limited time to read the slides and after that one volunteer student from each group came and presented what they discussed and understood. In this way, the teacher came to know about student learning in classroom. He used daily life examples in his classroom.

Lecture # 29

Topic: "Innovation in education"

In the book, **'Creating Innovators' by Tony Wegner,** It is mentioned that the most innovative companies in the world today are:

1. Apple
2. Google

He interviewed these companies to find out the reason why they are so innovative. There is a need for innovation in every field today, whether it is economy, weather forecast, flood controls, education or medical etc. To find out new solutions to everyday problems one needs to be innovative.

Need for innovation in society and education:

Innovation is defined as "the process of making changes to something established by introducing something new." It applies to "…radical or incremental changes to products, processes or services." Over the years there have been many changes in the way education is designed and delivered in different parts of the world.

Today, technology is a significant driver behind change, and can play an important role to bring innovations in educational design and delivery. There are immense possibilities for greater and wider-spread change with the use of present-day technological advancements, as well as with the implementation of innovative educational programs. The challenge is to ensure that innovation plays a constructive role in improving educational opportunities for billions of people who remain under-served in a rapidly developing world.

It is very difficult task to create innovators. The most popular University internationally for innovative students is Stanford.

Quotation from the book, **'Creating Innovators' by Tony Wegner:**

"According to the most recent estimates, real median household income has declined nearly 11% in the last decade. With a disappearing middle class, income inequalities continue to grow in the United States. More than 37% of young families defined as fewer than 30 are living in poverty, the highest level on record, and they are disproportionally African Americans, Hispanic and Native Americans. The total number of Americans living in poverty, both old and young, is now more than 15% of our population, the largest figure in the 52 years that poverty estimates have been published.**"**

In this book, all the problems of African Americans are highlighted related to poverty and education. The only solution according to Tony Wegner is that there is a need for innovation to address and solve these problems.

When Apple and Google companies hire employees, they observe the following characteristics in them:

Profile wanted by Apple and Google:

- Innovation (must be innovative, creative)
- Collaboration (must be able to collaborate)
- Communication skills(must be able to communicate his innovative ideas with colleagues)

Such innovations cannot take place alone. One need to work as teams to communicate and collaborate in problem solving. All the aspects of the problem are identified clearly and then innovative solutions are provided.

Innovation for ‘Learner-Centered’ Education:

How can innovation and technology offset the barriers of access and mobility that has been a deterrent to education in many parts of the developing world?

With the emergence of smart phones, eBook readers, Internet and low-cost computers, as well as solar electricity, cell phone access, and other technologies, comes the opportunity to provide education to assist individuals and communities in places under-served by traditional educational institutes. Technology and other innovations enable educational design and delivery to be adapted to the needs and environment of students enrolled in Open and Distance learning (ODL) and traditional educational programs. Thus, technology can also help programs shift to a ‘learner-centered’ approach to education.

Lecture # 30

Topic: “Application of technology in education”

The children who go to Punjab high schools is 20, 00,000. Government of Punjab is subsidizing the books for children and almost 20 crore is being spent on it. If these books are replaced by electronic books, there will be no printing cost and the only cost will be of interface. The quality of education and the matrix which are collaboration, communication, discovery, critical thinking, problem solving etc. are taught to school going children.

In America, according to 2007 Consensus, 20 lac children are home schooled. According to the following reasons, their parents do not allow them to go to school:

- Inappropriate school environment
- Bullying
- Lack of religious and moral instruction
- Dissatisfaction from school instruction
- Special needs of children
- Physical and mental problems of children

In the book “Now You See It” By Kathy Davidson, it is written that, “Games are the most elevated form of investigation”

Albert Einstein

More on the above quotation:

Albert Einstein is talking about philosophical games. Many philosophers have discovered that such questions which seem to be intractable can be solved through games. They say that games are the purest form to check intellectual abilities.

Quotation 2:

“She advocates games for all forms of teaching and all forms of learning, insisting that game mechanics apply to all actions online and offline, from simplest to the most complex global social actions. She advocates using games to teach collective decision making and responsible action in the world, and she hopes to introduce students to the joy of activist learning.**”**

McGonical

McGonical is a game designer and a social evangelist, who believes that “reality is broken” and that the best way to fix it is by playing games. (Now You See It book)

With the Ph.D. from the University of California-Berkley, she has had an epic wins in designing games for business, the arts, entertainment, social causes, environmental purposes, and political movements. For her, games are the solution to many of our problems; if we were all gamers, we could cure a lot of problems in society. She believes that if from infancy on, we all played games

as if our life depended upon them – especially multiplayer collaborative games – we would learn that challenges never stop, and that it is worth risking utter failure in order to have an epic win.

She believes that once you experience an epic win, you have the confidence to be fearless and unstoppable, not just in the next game, but in the world.

For example:

World without Oil is a computer game which was launched on April 30, 2007 and concluded on June 1st 2007. It imagined the first thirty two days of a cessation in the production of oil worldwide. Over a hundred thousand players eventually contributed to the game, completing 1,500 complete scenarios, all with different global and local consequences. These scenarios are all archived and can be downloaded. They are so realistic and so well informed by research, experience and the science and sociology of environmentalism that they are now used by educators in courses at all levels and by policy makers who use them to train for informed decision making.

Use of technology in different models:

1. **Virtual University Model:**

Virtual University can cater to million students at the same time. The Virtual University of Pakistan delivers education through a judicious combination of broadcast television and the Internet. VU courses are hand-crafted in meticulous detail by acknowledged experts in the field. Lectures are then recorded in a professional studio environment and after insertion of slides, movie clips and other material, become ready for broadcast. Course lectures are broadcast over free-to-air television and are also made available in the form of multimedia CDs. They can also be made available as streaming media from the Virtual University's servers. The multiple formats allows for a high degree of flexibility for students who may view the lectures at a time of their choosing within a 24-hour period. Additionally, students can use the lectures to review an entire course before their examinations – a facility simply not available in the conventional face-to-face environment.

In addition to the prescribed texts, comprehensive reading material / lecture notes in the form of web-enabled content are provided through a comprehensive Learning Management System (LMS) hosted on the VU Web Servers and accessible over the Internet. The full power of hyperlinks is utilized for making the on-line experience truly powerful. The LMS also provides an e-mail facility to each and every student as well as discussion boards for interaction within the VU community.

Assignments are handed out through the LMS and also submitted by the students through the same mechanism. Pop-quizzes and practice tests are also conducted through the LMS.

Midterm and Final Examinations for every semester are conducted in a formal environment at exam centers designated for this purpose throughout the country. Invigilators appointed by the University conduct the exams. The formal examination atmosphere assists in critical quality assurance of the student assessment system.

Advantages of the above model:

- Many students can benefit from teaching regardless of their physical locations.
- Additional costs are required for recording of lectures such as camera men, makeup etc. But the benefit of it is that not only a classroom of fourty students but 40,000 students can listen to your lecture at a time.
- Examination is carried out from a question bank prepared by experts and can easily measure students understanding during the semester.

Disadvantages:

- In conventional classroom, pace of the lecture can be changed according to students interest but the recorded lectures cannot be changed
- If a teacher is allotted to teach a course, he will keep the same notes for not more than three years, and after that some substantial changes are made in it. But in recorded lectures it is difficult to make changesbecause recording is a long term procedure.

In short, advantages and disadvantages of VU model are:

VU model Advantages	VU Model Disadvantages
- Teaching and testing resources are made available to masses	- No instant feedback
- Scalability	- Difficult to update courses after a certain period of time
- Centralized examination instruments	- No interactivity during the lecture
	- No collaboration
	- Lacks social presence

Khan Academy Model:

Khan Academy is an organization on a mission. “We're a not-for-profit with the goal of changing education for the better by providing a free world-class education for anyone anywhere.”

All of the site's resources are available to anyone. It doesn't matter if you are a student, teacher, home-schooled, principal, adult returning to the classroom after 20 years, or a friendly alien just trying to get a leg up in earthly biology. Khan Academy's materials and resources are available to you completely free of charge.

How it works for students

Students can make use of the extensive library of content, including interactive challenges, assessments, and videos from any computer with access to the web.

Advantages:

- Effective communicator
- Khan Academy assumes that there must be a computer or laptop for every student, whereas VU has established centers for students all over the world.
- Instant feedback. Vu does not provide instant feedback
- It is easy to update the lectures of Khan Academy while VU requires a lot of production cost.

Disadvantages:

- It eliminates the social interaction that must be present in classroom.

How these models can be improved:

These models can be improved if the focus is on the following:

- Interactivity
- The recorded lectures of Vu or Khan Academy must be build in with instant feedback
- Examination
- Collaboration
- Communication
- Problem solving
- Inquiry
- Critical thinking

Lecture # 31

Topic: “Learning through games”

A child is reading something about football in a book. His imagination about football is useless until he has a direct interaction with the play. He goes to a park where he meets his friend and starts playing football with him, now competition between them starts. Competition encourages motivation. When he starts playing with friends or team there is social interaction also. Social interaction gets enhanced and there is communication and collaboration between them while playing. He tries to achieve the target by beating the other friend. If he fails to beat his friend, he is not disappointed as he has tried to achieve his target to the maximum. There is also an element of emotional satisfaction. He gets instant feedback on his actions. All the steps mentioned in the above example are important for learning. Following are the important aspects to maximize learning:

- Games can promote learning. There is no emphasis on physical education in our schools. All the British Public Schools have a clear emphasis ‘games are always as important as academia’.
- Social presence of teacher is important in classroom whether it is a conventional classroom or an e learning classroom. A teacher can collaborate with the students at the same time while teaching. It maximizes students learning.
- Cognitive presence: when students start thinking in classroom the teacher must communicate his expectations to the students to promote critical thinking.

The Art and Science of Teaching / Using Games to Enhance Student Achievement

Games are a regular part of students' lives, no matter what their grade level. Students play games throughout the day on their computers, Internet, and their cell phones. One of the few places they don't regularly play games is in their classrooms. Although some teachers use games as a part of their instructional repertoire, most teachers do not, and those who do include them may not be using them to their potential.

Defining games:

- A form of competitive activity or sport played according to rules.
- An activity that one engages in for amusement.

There are certain rules to follow in games and there is an objective that needs to be achieved.

What is Game-Based Learning? It is known as a Game-Based Learning (GBL) the learning method of using games while teaching a subject. Games that are used for this purpose have been designed with the idea of achieving learning outcomes.

Some benefits of using Game-Based Learning

- **Gets student attention.** Students are easily engaged in game activities due to their willingness to play.
- **Students get a positive experience about learning.** The use of games encourages students to keep learning and erases the idea that learning is boring.
- **Rememorize concepts or facts.** Activities such as solving a crossword or alphabet soup are more engaging than a regular test. Prepare some contests such as "Who wants to be a millionaire" or "The wheel of fortune". Encourage students to work in teams to achieve the goal where their **knowledge is the clue to succeed**.
- **Reinforce and consolidate knowledge in a friendly environment.** The most effective way to turn content into something **meaningful** is to find out where and when to use it. With games students can reinforce and consolidate their knowledge through practicing and getting reward for their achievements.
- **Understand the consequences of our choices.** Using games enables users to understand the consequences of their choices. In other words, the students **learn through experiences**, through trial and error. Games offer a safe environment to test and **learn through mistakes** so that the information becomes meaningful as students understand its use.

Story, Drama, Narrative, Games:

Narrative:

When relationship between the concepts moves in a same direction it is known as a narrative. For example, a narrative in mathematics can be given as start with counting, then addition, combining counting and addition will result in multiplication, combining subtraction and counting results in division. Connections are at the heart of narrative.

Narratives help in:

- Better memorization/memory
- Rich understanding
- Triggering complex and larger in number mental operations when the student stumbles upon the same concept later.

Types of narratives:

- **Logical narrative**
- **Temporal narrative**
- **Spatial Narrative**

Story:

When there is a human motive in the connections of narrative, it becomes story.

- An account of imaginary or real people and events told for entertainment.
- A report of an item of news in a newspaper, magazine, or broadcast.

Drama:

- A play for theatre, radio, or television.
- An exciting, emotional, or unexpected event or circumstance.
- a composition in verse or prose intended to portray life or character or to tell a story usually involving conflicts and emotions through action and dialogue and typically designed for theatrical performance

Lecture # 32

Topic: “Pedagogy of Drama and Storytelling”

Definition of Drama:

Drama is an art form that explores human conflict and tension. It generally takes the form of a story presented to an audience through dialogue and action. The story is conveyed using the elements of the theatre: acting, costumes props, scenery, lighting, music and sound.

Drama has an emotional and intellectual aspect on both the participants and audience members. It holds up a mirror for us to examine ourselves, deepening our understanding of human motivation and behavior. It broadens our perspective through stories that portray life from different points of view, cultures, and time periods.

Definition of Drama Education:

Drama education uses the art form of drama as an educational pedagogy for students of all ages. It incorporates elements of an actor’s training to facilitate the students’ physical, social, emotional, and cognitive development. It is a multisensory mode of learning designed to:

- Increase awareness of self and others
- Improve clarity and creativity in communication of verbal and non-verbal ideas; and
- Deepen understanding of human behaviour, motivation, diversity, culture and history.

Storytelling as a Pedagogical Tool

Storytelling is a powerful pedagogical tool. Simply put, storytelling is delivering information in an organic form. The teacher, the storyteller, and the performer share a similar purpose: to inform, engage, and entertain their audience. They all seek to communicate their message in the most compelling and provocative way possible. Telling a story engages the audience in a unique way. Storytelling, then, is yet another device in the repertoire of a good teacher. It is not only a potent tool for the teacher as a way of organizing information, but as a dynamic means for students to express what they have learned. The magic of storytelling changes the atmosphere in the classroom and in so doing enhances the learning environment. Stories serve to open the mind so that the hearer is ready to take things in. In short, stories appeal to the heart, and, once the heart is won, the mind is open to learn!

Stories promote lively imagination on the part of students. When students listen to a story, they create mind pictures, make inferences and predictions, and fill in the gaps. They in a sense become involved in creating the story, thus forming a relationship with the narrative. When packaged as a story, the oral delivery of information promotes greater involvement than does written language.

In order to appeal to different learning styles, it is necessary to transcend the traditional presentation of fact and theory. Stories are concrete; they exemplify concepts better than abstract, non-creative methods. Teaching storytelling also teaches presentation, communication, and writing skills. Using storytelling as a method of instruction and assessment supports educational objectives. These include:

- improving verbal skills
- gaining self-confidence
- discovering the meaning of events
- developing a love for language and stories
- encouraging higher levels of cognitive thinking
- gaining a more in-depth understanding of narration
- improving imaginative skills
- internalizing the traditional structure and conventions of stories
- improving writing skills
- encourage active participation in the creation of stories

Storytelling is such an effective tool for the teacher because it is a powerful form of communication. Both the student and the teacher benefit from it. Students learn from hearing stories because they pay closer attention, understand the message more readily, and retain key points longer. Teachers become better educators because being able to tell a story effectively enhances the perception of the teacher as a leader. A teacher who can adeptly tell a tale reveals an approachable, likeable, and human side to his or her personality. This helps to close the distance between the teacher and the students by making the teacher's status less threatening.

Lecture # 33

Topic:”Pedagogy in education”

In the book “Pedagogy of the Oppressed” By Paulo Freire, it is written that

- The teacher teaches and the students are taught.
- The teacher knows everything and the students know nothing.
- The teacher thinks and the students are thought about.
- The teacher talks and the students listen and listen meekly.
- The teacher disciplines and the students are disciplined.
- The teacher acts and the students have the illusion of acting through the action of the teacher.
- The teacher choses the programme content and the students who were not consulted it adapt to it.
- The teacher confuses the authority of knowledge with his or her professional authority.
- The teacher is the subject of learning process while the pupils are mere objects.

In the problem posing education people develop their power to perceive critically the way they exist in the world with which and in which they find themselves. They come to see the world not as a static reality but as a reality in process, in transformation.

The two educational concepts and practices under analysis come into conflict.

Another book, “Now You See It” by Cathy N. Davidson, it is discussed about a newly open school, in which there are 100 students. There philosophy of teaching is quite different. The author wrote about a teacher:

Mr. Gemaine believes that we all need to take education seriously and that every child, including each 6th Grader in Voyager Academy, needs to view learning as the key to a future whose destiny she holds in her own hand. That’s how Mr. Germaine teaches, with the intensity of someone who believes that, individually and collectively, we are responsible for our civilization’s survival. When I ask him what his standard for success is , his answer was simple: “Perfection! I am taken aback, but as I watch the class unfold, I understand that he challenges each child to find a perfection of his or her own. No aiming for the A, B, C or D here. The bar is set at how high we can go.

An activity to build a bridge with the help of ice-cream sticks is given to the students. They are given choice to work individually or in groups. Now some students work in groups and lead their group to success in building the bridge.

But teachers in our Colleges or Universities follow a certain content to teach and to not try to go beyond it. Students are with different life experiences and prior knowledge but all are treated in a uniform manner which is not good for their educational career. So, Cathy addresses the system

of education that such system must be developed in which every student in given special and different attention.

Lecture # 34

Topic: “Problem-based education”

In hospitals, doctors use their knowledge of medicine and human body to diagnose diseases. They also use technology to check the symptoms of disease. The disease is like a problem that they try to solve.Similarly, when a problem is posed to a child, he has some choices corresponding to that challenging problem.

In the book, “Thinking Fast and Slow” by Daniel Kahneman, some problems with context are given; two of them are shared here for discussion.

Problem: 1.

A bat and a ball cost 1 dollar 10 cents. The bat costs 1 dollar more than the ball. What is the cost of the ball?

Problem: 2.

If it takes 5 machines, 5 minutes to make 5 widgets. How long it would take 100 machines to make 100 widgets?

Students of Pakistan who live in cities have protected lives, they study in well known institutions and they go to school in a protected environment. They do not know the real challenges faced by other children of Pakistan who are not able to go to school. In villages, children do not give money to the shopkeeper rather they deal in barter trade. They know the current rates of wheat that they sell to the shopkeeper to buy things. They know the rates and are very sharp to calculate. They do their calculations very quickly and without the use of paper and pencil.

Now if the language of posing problems is their everyday language then students would be able to give the right answer. The prior knowledge of children who lives in villages or in backward areas is sufficient to understand a new concept. But we do not try to use that prior knowledge for their learning; instead we start with the simple concepts of teaching addition and subtraction which has no connection with real life situations. If these concepts are taught with the help of their real life experiences then it would last in their minds for a longtime. Our education system snubs the creativity in classroom and motivation for questioning in classroom

Importance of prior knowledge:

- Curriculum should be connected to community.
- Former knowledge of students is developed very strongly but the application of knowledge is not up to the mark because connection is not made with real life.
- In Italy schools, it is a tradition to study the community first and then incorporate it into the curriculum so that gaining knowledge and application will go side by side.
- Students should be able to put in use the knowledge that they have gained.

- Interactivity presupposes that the learner has some degree of prior knowledge.

Assessing Prior Knowledge:

Students come to the classroom with a broad range of pre-existing knowledge, skills, beliefs, and attitudes, that influences how they attend, interpret and organize in-coming information. How they process and integrate new information will, in turn, affect how they remember, think, apply, and create new knowledge. Since new knowledge and skill is dependent on pre-existing knowledge and skill, knowing what students know and can do when they come into the classroom or before they begin a new topic of study, can help us craft instructional activities that build off of student strengths and acknowledge and address their weaknesses.

Once prior knowledge and skill is assessed, there is a range of potential responses, depending upon the type of course, the uniformity of results, and the availability and type of supplemental materials and alternatives.

Some facts n figures:

- In Pakistan 20-30 lac students reach high school.
- 30-50 lacs drop out and don’t reach high school.

While 40% of children are going to school the rest 60% who are majority are not going to school. Students can be attracted to school by making school environment attractive, meaningful content should be taught to reduce the drop out rates. The technique to standardize education for all is not applicable. But for the group of students who are diverse and to control the drop outs, education needs to ne centralized. While customizing, it is necessary to think that how technology or pedagogical skills can be implemented.

Lecture # 35

Topic: “How schooling can be improved”

A discussion with University Professors was made in which some questions were highlighted about schooling of children. Some of the questions and their discussion is included in this handout:

How can the future schooling in classroom improved?

We need to consider the historical perspective. The world is going through new advancements day by day, so one has to keep our self updated. Staying in the same situations such as 40 to 50 years back will make us suffer. Secondly, goal of education is dramatically shifted as society and industry is becoming sophisticated and to producing people for such society and industry is very challenging. What characteristics one needs to work in the future workplaces? Thirdly, we never try to gage the impact of education on outstanding students. Learning pedagogy has an impact on average students and not on outstanding students. The role of the teacher is to advance the level of learning of average students.

The major problem here is that teachers in classroom are unable to excite the students. It is the duty of the teacher to enhance the level of average learning students and made them think critically. They must be taught in ways that increases creativity. Moreover, they need to learn about communication, innovation and collaboration.

What are the major stages in schooling that needs improvement?

The first thing highlighted in this discussion was classroom environment in which a teacher is present; there is teaching presence, cognitive presence and social presence, and the book which the students read after class hours. Classroom atmosphere is almost damaged in our well-known schools and the textbooks are not up to the mark as well.

- The first stage discussed was that the books must be interactive.
- Students should be excited need to be enabled by teachers to discover.
- Information access point must be other sources as well as schools.
- Interactivity must be present in teaching.
- Transformation of knowledge can be possible in areas where school buildings are far away through online or mobile schooling.
- Smart devices can be applied to learning.

There is an area in Lahore where Muslims and Christians live. They are living peacefully. A child from that area is working in a salon. The reasons why he did not go to school are:

- Could not study in a conventional school
- He cuts hair from 11 am to 11 pm

He says that he has time in the morning till 11 am to study. When asked, what does he want to study? He says that he wants to improve his English Language. His brother is teaching in a school and he says that he can teach him spoken English in 4 months. He has taught through computers, there is a software in which the words are spoken and then the students spell and read the words. He is a street smart child who has a mobile phone with internet connection. He used Facebook and twitter on that. He has no training on it but with the passage of time, he knows how to use these social sites.

So, in this way, without any training, people design such elements of innovation with trial and error.

Similar with the above example, there are two children who work on a general store, a boy who is a garbage picker and a maid at home who has a mobile phone and Wi-Fi in it. They use it to access their neighbors' internet connection. Someone who accesses internet everyday can use it for the sake of learning as well. If these people are empowered to learn through the tools available to them e.g. a mobile phone and a Wi-Fi, they can learn on their own. In this way a large number of population who cannot afford conventional teaching can learn as well. The problems which are hindrance in their learning can be resolved through technology.

- In non-traditional education, flexibility is a key factor.

The children who use mobile internet use such activities that they know and understand, the rest is ignored by them. In conventional teaching the accreditation time is so long and one has to study for one year to be promoted to the next grade. Flexibility can be incorporated while thinking about the technology design.

With reference to NY Times, an article was written, Cathy Davidson wrote in response to it:

Teachers Should Change How They Teach Students Today. That's Our Job: Response to NY Times, Cathy Davidson wrote:

In conventional teaching, there is:

- Accreditation
- Assessment
- Rules and regulations

Cathy says that the above mentioned points demonstrate a very apologetic approach. We have made education so dull and boring that unless all these formalities are not fulfilled, the system cannot work.

Lecture # 36

Topic: "Technology in Education"

Modern classroom doesn't mean modern school building in a well known area. But modern classroom can be anywhere, where modern teaching and learning tools can be used.

An experiment on technology in Ethiopia:

Almost 8000 Motorola Zoom Tablets were distributed among children. These were distributed in an area where very poor families lived. There was no proper schooling in that area.

The boxes were left in the village. Closed, tapped Shut. No instruction, no human being. I thought, the boys will play with the boxes! Within four minutes, one kid not only opened the box, but found the on/off switch. He'd never seen an on/off switch before. He powered it up. Within five days, they were using 47 applications per child per day.

Within two weeks they were singing ABC songs in English in the village and within five months they had hacked Android. Some idiot in our organization or in the media lab had disabled the camera and they figured out it had a camera and they hacked Android.

Here we can assume that if children are provided with controlled conditions, they can learn anything without proper schooling.

Miles from the nearest school, a young Ethiopian girl named Rahel turns on her new tablet computer. The solar powered machine speak to her: "Hello! Would you like to hear a story?" She nods and listen to a story about a princess. Later, when the girl has learned a little more, she will tell the machine that the princess is named "Rahel" and she likes to wear blue—but for now the green book draws pictures of the unnamed Princess for her and asks her to trace shapes on the screen. "R is for Run. Can you trace the R?"

Then Rahel started writing her own stories. She listens to the stories, write her own and share.

The book tells her that she is very good at music, and her lessons begin to encourage her to invent silly songs about what she's learning. An older Rahel learns that the block language she used to talk with the turtle is also used to write all software running inside her special book.

Both the above mentioned findings on Motorola Zoom Tablets distribution highlight the shortcomings of our schooling system:

- If all the controlled conditions are removed, it is observed that learning still occurs. The process of learning never stops for those who want to learn.
- School means standardization of knowledge. Different landmarks are set and there is a time frame to achieve these landmarks/targets. Without technology, teachers still do not have evidence that the landmark is achieved.

News on NY Times about YouTube when blocked in Pakistan:

One notices consequence of this decision was that 215 people in Pakistan suddenly lost their seats in a massive, open online physics course. The free college level class created by a Silicon Valley start-up called Udacity, included hundreds of short YouTube videos embedded on its website. Some 23,000 students worldwide had enrolled, including Khadijah Niazi, a 11 years old in Lahore. She was on question 6 of the final exam when she encountered a curt message saying, "This site is unavailable."

Niazi was devastated. She'd worked hard to master this physics class before her 12th birthday, just one week away. Now what? Niazi posted a lament on the class discussion board: "I am very angry, but I will not quit."

In every country, education changes so slowly that it can be hard to detect progress but what happened next was truly different. Within an hour, a young man from Malaysia began posting detailed descriptions for Niazi of the test questions in each video.

There was a social presence in an online classroom. The variables of social presence are affected by generational change. We accept such social presences in which we spend time in our childhood. So, the new generations will have the powerful indications from online learning. With the passage of time, the social presence through online social networking sites will gain importance. Through technology, a social universe is created.

An instructor from Portuguese tries to help Niazi in a way that she can access YouTube through proxy sites. Another student from England named William also promises to help her.

None of these students have met one another in person. The class directory included people from 125 countries. But after weeks in a class, helping one another with Newton's laws, friction and simple harmonic motion, they'd started to feel as if they shared the same carrel in the library.

Together they had found a passageway into a rigorous, free collage level class and they were not about to let anyone lock it up.

By late that night, the Portuguese Professor has successfully downloaded all the videos and then uploaded them to an uncensored photo-sharing site. It took her four hours, but it worked. The next day, Niazi passed the final exam with the highest distinction. She was the youngest girl ever to complete Udacity’s Physics 100 class, a challenging course for the average college freshman. That same day, Niazi signed up for Computer Science 101 along with her twin brother Muhammad. In England, William began downloading the videos for them.

Lecture # 37

Topic: “A Preview of Problems of Education in Pakistan”

Three schools were visited for survey; major question that was asked from teachers is that what courses do you think are difficult to understand for students? What is their definition of understanding? If students are facing difficulty in a subject or topic, what pedagogical techniques should be applied to them?

The first school visited was Chritian Nagar High School, there was a school in every colony separately and there was a tough competition. It was like a branded chain of schools which is a good improvement in Pakistan. The problem highlighted by this school administration was that they want to increase their amount of learning. First thing is that they want to measure learning in classroom. And then they want to use such innovative tools which are not very expensive and let the students discover and learn thoroughly.

The second school visited had a chain of their branches everywhere in the city. The problem highlighted in this school was that they want to expand their schools. They think that some other schools which were started when this school was established had more branches than this school. The challenge of this school was that they want to cater the students who are from upper middle class. What should they do? Can they make conventional schools in any other area? The infrastructure of school is not difficult for them but the actual learning in classroom is a challenge. Second option is that they must not spend whole money on the infrastructure of schools rather they can utilize the 20-30% of it on innovative pedagogy and technology to maximize students learning. And the constructed building of school must not be corresponding to the conventional school building.

The Third school visited had three to four branches only and it also caters the students from upper middle class families. The challenge addressed by administration of this school was quite different and it was that their income had reduced in the last few months for an unknown reason. The problem here is about management in which pedagogy and technology also contributes a lot. The first problem here is managing growth of the school. They do not want to do it in a standardized way rather they want to leverage growth through innovative technology.

The system of this school was observed carefully, there was a building for teachers in which students study in a conventional manner. Another building is there is which no teaching staff is present and there are only content designers. They used to observe different books of matriculation or O’levels and then try to create their own content. These are experienced people who have teaching experiences at University level. These people claim that they can work hard for content development. They are not using any innovative technology or pedagogy. A question arises in mind that how much the content material developed by these people is effective? They replied that we are doing this task since 40 years. Doing a same task for 40 years does not

guarantee you that you are doing it effectively. Is there any quantifiable measure through which you can easily demonstrate the effectiveness of teaching and learning?

There are two ways one is that they must do it experimentally; secondly there have been many researches on the learning theories since 15 years. But in their system or content development section, these theories were not given importance. They are just observing other books and then creating content for their schools.

The level of understanding is measured through examination in our schools. But students who get good grades in classroom sometime do not have enough knowledge to apply the knowledge in real world settings. With the use of technology, it is possible to assure at least lower level of understanding of students.

Teachers from this school highlighted some of the topics of mathematics, physics and biology which they feel that students feel difficulty. It was inquired about linear graphs from teacher through email that what topics are required as prerequisites. They wrote:

“You have asked about the responses of students while studying this chapter. Although it is not difficult for them to understand the concepts.

Overall they have some problem in the selection of scale according to different coordinates, especially in conversion graphs; where different fractional values also are involved.”

Now they proposed a list of concepts that students must know to understand linear graphs and their applications. There are:

- Cartesian plane
- One to one correspondence
- Four quadrants
- Cartesian product
- Ordered pairs
- Scale of graphs
- Construction of tables satisfying linear equations
- Conversion units
- Graphical solution of linear equations

Almost all these concepts are interlinked with each other and students have enjoyed this chapter. I think that they have some problem in understanding the slope of the equation.

Then it was asked from the teachers that what sequence you follow while teaching this chapter in classroom. They say that the following sequence is followed:

- Cartesian plane
- Cartesian product
- Ordered pairs

- Coordinates
- Graphical solution of linear equations
- Dependent and independent variable
- Abscissa and ordinates

There is no connection in the above mentioned sequence of topics.

Objectives of this chapter given in the Punjab textbook of 9^{th} class are:

- Draw a graph of an equation of the form $y = c$
- Draw a graph of an equation of the form $x = a$
- Draw a graph of an equation of the form $y = mc$
- Draw a graph of an equation of the form $y – mx + c$

Teachers claim that students understand all of these. Cognitive, teacher and social presence is necessary in teaching and learning process. The major aspect is that when teacher enters the classroom, he must present a scenario through which students got excited and interest in the class is developed. Students must get excited that the presented problem is most similar to the daily life problems.

Lecture # 38

Topic: “Teaching the handicapped”

A handicapped girl was doing PhD from NUST; her motivation was to complete her studies using technology. She was the student of School of Electrical Engineering and Computer Science. She wanted to cater for learning solutions for handicapped children regardless of their ages. Technology can be used to measure classroom learning as well. When lectures are delivered in a conventional classroom in which a teacher delivers a lecture and pedagogy is not changed. The students only listen to the lecture, and meaningful learning does not take place. Such conventional lectures are still delivered in our schools that has made the students handicapped of their thinking.

- The main idea that needs to be taught to the students. Teacher needs to decide the most suitable route through which students can learn the concept meaningfully.

The core courses taught at University level are open ended. Many courses require reading but intensive in which if the topics are of learner’s interest, they proceed further easily.

Secondly, pedagogy to teach the courses plays an important role in student learning. The practitioners should know all about pedagogy in detail. There is a variety in pedagogy the teacher can give projects to the students or can teach through problem-based learning. It is the responsibility of the teacher to take the bottom students with the other students effectively in learning.

For example if I am learning Pakistan studies then there must also be a change in my civics behaviour so that I can relate today’s news with the history. Similarly to learn mathematics you should be able to break down the real world situations into its mathematical symbols.

A teacher must take into account the following:

- The method adopted to teach the concept must delivers effective learning.
- How can the teacher change the pedagogy rapidly from one topic to other topic?
- What existing technology tools are available that can be adopted in the classroom?

A school administrator must think about:

- What technology tools are helpful for students learning and can be used easily in school?
- How effectiveness of teaching methods can be measured in school?
- How teaching can be assessed with the use of technology?
- If an administrator wants to improve the skills of teachers, how it can be done?

In Canada, teachers are trained to teach the handicapped. At first, there is a general training of how to include the handicapped in a classroom. They try to involve as all the students in the mainstream of education. It is proved that handicapped students can learn in an ordinary

classroom with some additional use of technology. It is taught as a subject in Canada at graduate level.

Teaching students with Physical Disabilities:

To maintain inclusive classrooms, teachers should have knowledge of physical impairments, assistive technology, teaching strategies, and necessary accommodations and modifications.

Children with physical disabilities, once taught in separate classes and even separate schools, now learn beside their peers in regular classrooms. Inclusion has changed how these students are educated, with the continuing development of the Individuals with Disabilities Education Act (IDEA) ensuring rights to a quality education.

As types of physical disabilities vary in degree of impairment, teachers need to have a general knowledge of various conditions and how they affect children. Assistive technology can facilitate these students by allowing them to participate in the classroom activities easily and independently. Specific classroom and instructional strategies, as well as accommodations and modifications, also assist the students in achieving their best individual educational outcomes.

The Practice of Inclusion

With the development and reauthorization of education laws, such as IDEA, inclusion has become the typical practice in educating students with disabilities. Unlike mainstreaming, inclusion offers students support services to assist them to function in the general classroom. In an inclusive classroom, general educators set the tone to create an accepting learning environment that benefits all students.

Assistive Technology

Any device or tool that enables a student to participate in the learning activities can be called assistive technology. Simple pencil grips or ergonomically designed pens can make holding and manipulating writing instruments easily. Oversized art supplies and handmade adaptations can allow students with fine motor difficulties to create art.

For those with more severe impairments, assistive technology lets students have access to computers for learning and expressing themselves. Keyboard and mouse alternatives replace standard input devices. Voice recognition software allows users to speak what they want to input instead of typing on with a keyboard.

Classroom and Teaching Strategies

Teachers can significantly improve educational outcomes of students with physical disabilities by implementing specific strategies. Classroom arrangement with easy access to supplies can prevent accidents and improve participation in activities. Using a buddy system or working with paraprofessionals can provide students with necessary assistance to complete assignments. Finally, individual accommodations and encouragement can promote learning and ease frustrations due to physical difficulties.

Accommodations and Modifications

Since each student differs in degrees of impairment and ability, accommodations and modifications must be individualized according to needs. Although some subjects are more difficult to accommodate and modify for certain disabilities, many options make learning accessible. Accommodations can include note takers, the use of scribes for written assignments, handouts in alternative formats, and separate rooms for testing. A teacher’s creativity also opens new opportunities to learn.

Adaptive Physical Education

Physical disabilities should not exclude students from participating in gym activities. Depending on a student’s disability, a separate, adaptive class or modifications within a typical gym class can offer physical education. Basketball, golfing and tennis can be adapted so that students can participate with the assistance of a physical education teacher or aide.

Lecture # 39

Topic: “Discovery based Collaborative Learning”

“Guide to e-learning” by Michael Allen, and “E-learning in the 21st century- A framework for research and practice” by D. Randy Garrison through light on the importance of e-learning.

Why e-learning? World peace:

- It is tempting to add it to the list because peace is dependent on understanding and understanding is the product of learning.

The book by Michael Allen emphasizes what the developers of e-learning modules should keep in mind:

- Understand what is possible in e learning
- Know how to avoid spending money on e-learning
- What you can demand in an e-learning environment?
- How can you evaluate e-learning projects?
- How can you measure and compare e-learning situations?

Drawback of old versions of e-learning models:

- Communication, collaboration and exchange of ideas lacked in the older version of e-learning

Now in the last 5 years with the use of internet, you can not only communicate with the teacher but also with other people learning the same disciplines. The power to communicate and compute has enhanced e-learning due to internet.

Discovery based collaborative learning:

To implement this approach an experiment was done in UET. Whole class was divided into 4-5 groups and then the teacher tried to take them all along as they are travelling through leaps. The teacher did not give them all the knowledge rather had to discover knowledge on their own. The students learn better in collaboration with the other group members, instead of individual learning. It is necessary for the teacher to observe that there is collaboration and communication among the group members. Teacher needs to monitor the students so physical presence of teacher is necessary.

Another group of students’ implemented discovery based collaborative approach in a virtual mode. An online group was made by the students so that they can communicate with one another and make notes. If a group member identifies a difficult point in discussion, the other member try to help him which brings in mo0re discussion points. In this way the process of discovery based learning continues. When writing comments, different colors were assigned to students so that the teacher can identify the input by each student. The teacher needs to highlight the mistakes of students so that correct concepts are developed.

It is necessary to provide different types of communication channels to the students. If students are limited to a certain channel then their interest in learning will gets limited. Social communication plays a very important role in learning. Students do not only rely on the teacher but learning a shift from ‘teacher to learner’ and then from to ‘learner to learner’.

Lecture # 40

Topic: "The Community of Inquiry of Faiz Ahmed Faiz"

Pitrus Bukhari was a very famous professor of Government College University, Lahore. He created a social and cognitive presence in the University.

When people around us think critically and in-depth about the ups and downs of life the product of such thinking is highlighted in the poetries of our poets. One of the most famous poets is Faiz Ahmed Faiz who wrote about the people who are unable to attend formal schooling but if provided with the opportunities and resources, they can do wonders. Every person in Pakistan today has cell phones and most of them have Wi-Fi in it. If such people are guided properly to use these devices for their education their skills can be developed.

E-learning facilities and community of inquiry must be developed for these learners that includes social, cognitive and teacher presence.

The three contexts of learning discussed earlier are:

- Firstly, the street smart children who cannot attend formal schooling but are intelligent enough to use the facilities for their future benefits and education.
- Second is the girl Khadija Niazi, who was studying an online course but suddenly due to some reasons YouTube was blocked. People around the world started to help her out in her difficulty by providing her lectures and notes through other sources instead of YouTube. It was a good example of cognitive presence among the students of the same course.
- Third is the websites where well known Universities provide online certificate courses.

In the book, "e-learning in the 21st century" it is written that:

- E-learning has some inherent capabilities; the way to discover these inherent capabilities is our task.
- It is a complete transformation of learning

It is totally a new paradigm on which the following report is proposed:

US web-based Online Education Commission:

- The question is no longer if the internet can be used to transform learning in new and powerful ways. The commission has found that it can. The Web-based Education Commission calls upon the new congress and administration to embrace an e-learning agenda as a center piece of our nation's federal education policy. (July 2001)

Deeper learning:

In comparison to the previous educational methods, today the methods to evaluate the deeper understanding of students have changed as well. Computers are helpful in providing the interactive learning experience, and Internet opens the channel for communication. The combination of these two has provided us with totally different learning tools from the past. So, the depth of understanding can be far more than it was possible previously..

Limitations of Todays Schooling:

- The main purpose of teachers is to cover the syllabus rather than educating the students to discover and communicate new ideas.

In E-Learning in the 21st century, it is written that learning takes place in:

- A community where individual experiences and ideas are recognized and discussed in light of societal knowledge, norms and values; where autonomy and collaboration are not conflicting or contradictory terms but are essential elements of a unified and qualitative shift in the process of critical inquiry.

  Institutions of higher education have slowly begun to appreciate that the content alone will not define quality learning but the context; how the teachers design the learning experience and the interactions that derive the learning transaction, will ultimately distinguish each institution.

  A quality educational experience is the dynamic integration of content and context created and facilitated by a discipline expert and pedagogically competent teacher.

(Listen to the video lecture for the interview of Faiz Ahmed Faiz)

Lecture # 41

Topic: “Pedagogy of Faiz Ahmed Faiz”

When name of Faiz Ahmed Faiz came to mind it directly has the feeling of revolution, innovative and radical ideas and equality. In 1938 there was no concept of technology in education. Faiz addresses the poor and those who do not have many facilities in their lives in his poetry.

In the interview of Faiz Ahmed Faiz, the revolutionary idea addressed is that teachers were the common resource at that time and it did not matter that the teacher belonged to a particular institution. A teacher was the teacher of all students. All the students were also treated equally and the institutions that they belonged to didn’t matter.

The discussion forums at that time were made when the teachers and students sat together for discussions. It was known as ‘Majlis’ in which the graduate students were given the level of former teachers. In ‘Majlis’ a student dictated his thinking and ideas to all members present there in a specific context that he had faced or suffered in life. All the students benefitted from the source presented and the presenter got instant feedback which is very necessary in learning. FAiz Ahmed Faiz also says that most of their study was not based on formal classroom setting, and students learnt mostly through the libraries or ‘Majlis’ discussions and discussions with senior teachers.

Ways to make learning possible for all:

- Firstly, all teachers should be called at one place to share their ideas and all students should be welcome to attend. All students can choose the topics of their interest so that can benefit from the teaching.
- Teachers and students must not be specified to a certain college or University.
- Second thing to keep in mind is that students must be able to use their learning in such discussions so that others can give feedback.
- Students today rely on internships before entering the practical field. At the time of Faiz Ahmed Faiz the component of practical field was included in the curriculum.
- Students must have command of the soft skills as they must not hesitate to comment or ask questions in a discussion forum.

Use of technology for social interaction:

Such social interaction among teachers and students can be made possible through technology. A discussion forum can be online. For example, Facebook today is an online social website that provides the individuals with discussions but it does not serve the purpose of education. For the purpose of education the online course websites that are providing online certificate courses to the individuals serve the educational purpose. Social presence is an important aspect of online learning.

In the book, "e-learning in the 21st century", it is written that

"Because e-learning can be accompanied by the sense of aloneness, one of the first and most important challenges for the teacher is to establish social presence."

Social presence is also important as students observe and adopt habits of teachers as ideals. So, the responsibility of the teacher is not only to deliver the content but also the character building of the students.

In an e-learning class, there should be:

Step: 1

- Triggering event
- Sense of puzzlement
- Dissonance

Step: 2

Exploring the issue or problem by gathering and exchanging relevant information.

Step: 3

Integrating or making sense of information by connecting ideas in a meaningful way.

Step: 4

Resolving the issue by applying and testing the ideas either directly or indirectly.

Lecture # 42

Topic: “E-learning”

When you enter a high school classroom, you observe complete silence. If there is noise in the class it is said that there is no classroom management on the part of the teacher. A specific training to teachers is given on maintaining discipline in the class. Students most of the time just listens to the lecture and they are not allowed to talk or ask questions in the classroom.

Individual experiences include:

- Reading
- Writing
- Doing

The aspect of “Doing” can be included only by using effective pedagogical strategies in classroom.

In the book, “e-learning in the 21st century” by D. Randy Garrison, a classroom is discussed in which the social presence in classroom is highlighted.Classrooms such as physical or online in which students are getting educated have social, cognitive and teacher presence. The role of students is to construct knowledge. A student can use a tablet and an internet connection in which the skills of thinking, reading, writing and are used. If the personal level learning in a conventional classroom and a challenging environment of online education are mixed together, it can make a collaborative classroom.

Schools prepare students for real life. More and more jobs today are team and project oriented. So students need to learn how to work in teams. This can only be possible through collaborative learning in classrooms. A successful individual is the one who know the social skills and has also command on the content. Emotional Quotient is necessary to be fulfilled in the job market as compared to IQ. It is important to make it part of the school curriculum.

There is a need to teach discovery and collaborative learning in our conventional classrooms. In the traditional classroom, a teacher is always in command of the classroom. Technology and technology should never be in command. The key role of the teacher is to imagine the collaborative classroom where there is no silence, students need to communicate with one another and share their ideas.

Phase in an e-learning experience:

1. Triggering event/ Dissonance
2. Problem exploration and information gathering
3. Integrating and making sense of this information

4. Resolving the issue by applying the ideas either directly or indirectly

Basic rules in any class:

- Welcome the participants
- Encourage them to discover
- The role of the teacher must be of a facilitator

Lecture # 43

Topic: “Characteristics of an Innovator”

Quotation:

1. **“We shape our tools and thereafter our tools shape us”**

This quotation focuses on the use of smart devices like apple and macintosh. The new generation adopts the new technologies quickly.

2. **“No one has a finer command of language than the person who keeps his mouth shut.”**

In the book “The Innovation Secrets of Steve Jobs” it is written that according to a research done by Harvard research, one skill that separates innovators from non-creative professionals is ‘associating’. Associating is the ability to successfully connect seemingly unrelated question, problems or ideas from different fields. The more diverse our experience and knowledge is, the more connections the brain can make.

Fresh inputs trigger new associations. For some, these lead to novel ideas. The three year Harvard research project confirms what Steve Jobs told the reporter 15 years later – creativity is just connecting things. Here is what the researchers had to say:

“When you ask creative people how they did something, they feel a little guilty because they did not really do it. They just saw something. It seemed obvious to them after a while. That’s because they are able to connect experiences they have had and synthesize new things. And the reason they were able to do that was because they had more experiences or they had thought more about their experiences than other people. A lot of people in our industry have not had very diverse experiences… so they do not have enough dots to connect and they end up with very linear solutions without a broader perspective on the problem. The broader one’s understanding of the human experience, the better design we will have.”

He has spent a lifetime exploring new and unrelated things – the art of calligraphy, meditation practices in an Indian ashram, the fine details of Mercedes Benz. The three business professors who conducted the research for The Innovator’s DNA, which is also a book published in December 2009 (Harvard Business Review), offers an enticing comparison. First they want the reader to imagine that he has an identical twin, then imagine that identical twins have the same brains and natural talents and both have been assigned the task of creating a new business venture.

More on the above quotations:

Three things that emerge from these quotations are:

- First, when innovation takes place, it becomes obvious after a time. After that successful innovation is not questioned. For example, today children of same ages are taught in the same class that was also an innovation in education. As in the past, students in a class were from different ages because all people could not afford education. Now the obvious thing is that all children are divided age-wise in a class. Standardized testing is also another example.
- Use of technology tools does not amuse the old age people. For example, a librarian in a University when asked about digital books, says that even DAWN News is available online but he does not find it excited to read online.
- Todays’ generation wants the things to be more rapid as their attention span has decreased. New technologies has made this new generation very fast.
-

Quotation:

Cognitive presence is the heart of an educational experience that is creating and sustaining a community of inquiry where students are engaged in a collaborative and reflective process consists of four phases:

1. Practical inquiry which includes understanding an issue or problem.
2. Searching for relevant information.
3. Connecting and integrating that information.
4. Actually confirming the understanding.

The focus here is managing the process and monitoring the depth of understanding. This involves facilitating and focusing the discourse, providing appropriate insights and information when needed and seeking some common understanding.

Theory also suggests that start the learning with posing a problem. Searching data about the problem can include reading books or surfing on internet. Now at the third step they have to connect all the searched information with the issue or problem.

Lecture # 44

Topic: Traditional Teaching vs. Online Learning

In the book *Creating Innovators* the focus on innovators who brought a change in the world in the last 5-10 years. The schooling and the role of parents of these innovators is highlighted in the book.

In Pakistan, all of us have studied in a traditional classroom, and we have accepted it even though real learning hardly ever happened in the traditional classroom. Since feedback is not provided timely in the traditional teaching approach so the learning of each student is only assessed in the exams.

Access to Traditional Classrooms:

- The street smart children who are working in workshops, selling goods at shops etc. do not have access to formal education system and hence are deprived of schooling. There are inbuilt limitations of a traditional classroom.

How can emerging technology replace or improve the traditional classroom:

- Technology can provide instant feedback;
- Technology provides different learning rates;
- With the use of technology, for instance if a tablet is available a virtual class can start anywhere.
- Learning takes place even if the teacher has weaknesses in his teaching skills in a non-traditional classroom where technology is used.

Variables that impact a traditional classroom:

- Pedagogical strategies in the classroom;
- Social interaction between students and the teacher;
- Collaborative learning coupled with enriched social presence.

Importance of Social Presence in an Online Classroom:

The Instructor's Role

The instructor's role is critical to learning, whether it is face-to-face classroom or online. Studies on distance learning advocate that instructor-to-student, and student-to-student (social presence) interaction is a critical component of learning, as it improves the effectiveness of learning as well as learner satisfaction.

Instructor's Issues

The role of the teacher automatically shifts when the physical is replaced by the virtual classroom. The new role of the instructor is “redefined as a facilitator, organizer, and manager”. Online teachers need to realize their role in shaping the social aspects of the online classroom. The teacher plays a critical part in establishing social presence for the entire learning community.

Feedback & Time

In order to create a social link between students and the teacher, the teacher must take into account the isolation felt by students when online communication lags. If time frame expectations are not met, students feel less socially connected in an online learning classroom. Answering email with a shorter turn-around time is pertinent to fostering social presence in the online learning classroom.

Importance of Cognitive Presence in Classroom:

Learning is about mental operations. To get the most out of your online class, think about the different associations and meaning students are developing from the material and the discussions generated during the class. A large gap between what is presented and what is learned means that students aren’t cognitively involved in a class, as students may only be superficially interpreting content, thereby missing the overall intent of instruction. The effective delivery of instruction allows students and instructors to maintain cognitive presence within the classroom.

Steps to Create Cognitive Presence:

- Create a triggering event
- Explore the problem
- Integrate new ideas and meanings
- Come to a resolution

Lecture # 45

Topic: Problems of Learning Through Pedagogy and Technology

In his book, *Stratosphere* Michael Fullen says that to reduce inequality we need to use technology education and low cost resources:

“The problem of inequality is becoming more pronounced and more entrenched decade by decade. Deepening inequality is a societal time bomb. So far, technology has not been our friend because, as I argue in this book, we have not made it our friend“.

He predicts that in the near future, the losers will be approximately 90%, corporate profits will be 50% high while the income from labor will be 50% low. In short, there will be an irreversible shift from labour to capital. It is certain that no good can come out of this for the rich or the poor.

The slogan for online learning is: “Double the learning in the classroom, double the students in the classroom and half the cost.”

In his book *Creating Innovators* Tony Wegner discusses the characteristics of innovators. He has discussed the life of a Curt Philips who invented IPhone. He was the team lead of Apple innovators. Curt Philips was the eldest child in the family. His education was a challenge for his parents as he changed many institutions. Then he went to Stanford University and the courses there really excited him.

- He wanted to invent something for the betterment of the people.
- He studied computers as he thought that it was not a specialized subject like engineering and he could use it to solve a lot of different problems.

However, he could never see himself wanting to write code for google. Writing a code on a server that no one would ever see or interact with did not really appeal to him. He wanted to create products for people that they could hold and use so he started exploring robotics. For his Master’s degree, he took mechanical and electrical engineering classes and found out about embedded system design sequence called Smart Product Design and that was a turning point in his academic career.

Smart Product Design classes taught mechanical engineers, a little bit of electrical engineering and software engineering so that they could build embedded systems. These courses were the longest and hardest in the Stanford engineering program because se the classes required the most dedication.

Curt Philip was excited about these courses because his previous experience in Stanford engineering had been solitary in learning Computer Science. He describes this experience by saying that you go write a code but you could not be any further from the reality of real world engineering. How do I solve a political problem, a social problem and a technical problem all

together to deliver something? I had discovered that where I wanted to add value was at the intersection of things.

Being a PHD never appealed to him as he never wanted to spend five years becoming really deep in one area. He wanted to find ways to add value at the margins. What that meant practically in engineering is being an integration engineer. You bring these pieces together to create a product. These classes were great for him because he worked in teams on these multidisciplinary problems that required bringing together a set of tools to create a solution.

Creativity and innovation:

Creativity and innovation are at the heart of a powerful shift occurring in our lives as society is moving from an industrial economy to a knowledge economy (Sawyer 2006; Florida, 2002). Many educators in fields ranging from business to the arts, from the humanities to the sciences, feel the challenge of teaching students to be creative innovators. There is a growing recognition that in order to prepare our students for the demands of 21st century jobs, creative thinking, problem solving, communication, innovation, collaboration and critical thinking skills are as important as academic and technical skills.

Thus at the university level, the challenge of teaching students to be creative and innovative relies on faculty expertise in delineating elements of creativity and innovation as measureable learning outcomes and establishing appropriate assessment measures as higher education moves toward standardized learning outcomes and assessments. This challenge is also an opportunity for faculty to enhance the teaching and learning and the scholarship of teaching creativity and innovation. Creativity and innovation are life long skills and practices that promote not only individuals but also our economy.

How Can We Teach Creativity and Innovation:

1. Design Projects to Bring Out Creativity
2. Create a Culture that Promotes Creativity and Innovation
3. Scaffold for Creativity and Innovation