EDU654 Grand Quiz Fall 2020

1. The lecture will be communicated more effectively if teachers
   a) Read the prepare notes
   b) Prepare good notes in advance and use them as their guides
   c) Engage students in immediate discussions
2. ---------- are a very powerful support for thinking.
   a) Images
   b) Concrete things
   c) Entity
   d) Material
3. Teacher usually avoid hypothesis testing in classroom because it is ----------
   a) Time consuming
   b) Difficult
   c) Impossible
   d) Not important
4. The psychological state of asking questions in classroom is said to be ----------
   ----
   a) Problem solving
   b) Taking experience
   c) Giving feedback
   d) Testing ability
5. Metacognition is not important for:
   a) Assessment of learning
   b) Problem solving
   c) Teaching
   d) Rote learning
6. ---------- Technology is mostly used by non- consumers.
   a) Modern
   b) Disruptive
   c) Lower level
   d) High level

7. The shortest distance between two points is known as
   a) Distance
   b) Displacement
   c) Velocity
   d) Speed
8. For science subjects, ---------- method is followed to teach.
   a) Demonstration
   b) Lecturing
   c) Cooperative
   d) Socratic
9. Discovery-based learning is characterized by----------
   a) An emphasis on investigation of real-life situations
   b) A highly structured learning environment
   c) An emphasis on lifelong learning
   d) A comparative task structure
10. Thinking is driven by----------
   a) Answer
   b) Question
   c) Assessments
   d) Test
11. ---------- is the report of an item of news in a newspaper, magazine or broadcast.
   a) Story
   b) Drama
   c) Narrative
   d) None of the above
12. A teacher is teaching the concept of "melting and dissolving" in the classroom. She is asking questions from the students during lecture, which of the following is the reason of asking questions in classroom
   a) To engage and challenge pupil
   b) To promote memorization of exercise in classroom
   c) To check on prior knowledge
   d) To promote reasoning and problem solving
13. Computer system consist of:
   a) Hardware and software

b) Input and output devices
c) Processors and backing storage
d) Monitor, mouse, keyboard and processor

14. Visual system has a ---------- power.

a) Modeling
b) Unusual
c) Imperfect
d) Irregular

15. Successful educational practices evolve from the application of---------- methods.

a) Analog
b) Scientific
c) Virtual
d) Technical

16. In jigsaw technique, students are directly engaged with the ----------

a) Administrator
b) Material
c) Tech
d) Teacher

17. The thinking about the process of thinking is called ----------

a) Metacognition
b) Application
c) Analysis
d) Evaluation

18. Which part of thinking is concerned with lateral thinking?

a) Stimuli
b) Perception
c) Coding
d) Encoding

19. There are ---------- level of learning outcomes.

a) Two
b) Three
c) Four
d) Five

20. Which concept of the following was developed by Polya in his book?

a) How to use technology
b) Plan to solve the problem
c) How to give motivation to students
d) Plan for assessing the students

21. Rudyard Kipling was born in ----------
a) Bombay
b) England
c) America
d) Delhi

22. According to James E. Zull, learning means changing the ----------
a) Behavior
b) Grades
c) Situation
d) Brain

23. Teachers thinks about the method to teach is called as:
a) Coaching
b) Training
c) Tutoring
d) Pedagogy

24. The rate of rate of displacement is
a) Acceleration
b) Speed
c) Momentum
d) Velocity

25. ---------- is an important part of any learning process.
a) Reflection
b) Rote learning
c) Understanding
d) Memorization

26. The purpose of teaching is to facilitate:
a) Acting
b) Practicing
c) Learning
d) Teaching

27. Which type of questions force us to deal with complexity?

a) Short questions
b) Open ended questions
c) Deep questions
d) Dead questions

28. There are ----------categories of new technology
a) Two
b) Three
c) Four
d) Five

29. Which of the following concept was given by James E Zull?
a) Problem solving
b) Artificial intelligence
c) Understanding the brain function
d) Pedagogical content knowledge

30. Which option from the following is the art of teaching?
a) Content
b) Pedagogy
c) Technology
d) Assessment

31. What is the most important thing for the student's learning?
a) Drill
b) Rote memorization
c) Motivation
d) Understanding

32. There are ---------- stages of Poly's method.
a) Two
b) Three
c) Four
d) Five

33. Why will you ask questions from students during the course of the lecture?
a) Are the students carefully listening to your lecture?
b) To learn which one of the students is the brightest one
c) To learn whether students are understanding (the lecture) or not.
d) To assist the students

34. In which country of the world the most recommended book in high school is conceptual physics?
   a) China
   b) Russia
   c) Scotland
   d) United state
35. The average velocity and the instantaneous velocity of an object will be the same if
   a) The object's speed is constant
   b) The object's acceleration is zero
   c) The object's velocity is always positive
   d) They are never the same
36. Kinesthetic learning learn best
   a) By doing
   b) By hearing
   c) By using text and watching videos
   d) In calm, quite surroundings
37. Following is an example of a set except:
   a) All toys of Ali
   b) All toys of Nariman
   c) All friends of Ali and Nariman
   d) Multiplication of Ali and Nariman's toys with their friends
38. The time consumed in ---------- learning is worthwhile.
   a) Lecture
   b) Book
   c) Inquiry
   d) Discovery
39. Following are the generation of technology except
   a) Tube board
   b) Transistor
   c) Integrated circuit
   d) Computer
40. Without reflection, learning is only
   a) Activity
   b) Drill

c) Motion
d) Movement

41. If a teacher is teaching geometry to the students and she is not asking questions, what could be the reason behind it?

a) It requires a lot of skills on the part of the teacher
b) It encourage students participation
c) Provides the teacher with feedback
d) Participation engages students' interest

42. Metacognition is not important for:

a) Assessment of learning
b) Problem solving
c) Teaching
d) Rote learning

43. …… is the report of an item of news in a newspaper, magazine or broadcast.

a) Story
b) Drama
c) Narrative
d) None of the above

44. An explanation for why something occurs or how it occurs is called……

a) Theory
b) Concept
c) System
d) Scheme

45. We can stimulate our thinking with ……

a) Questions
b) Answers
c) Books
d) Journals

46. Hardware of a computer can be defined as:

a) The machine and programs making up computer
b) The parts of a computer system that you can touch
c) The operating system of a computer
d) The program needed to run the computer

47. Knowledge cannot be transferred; it can only be constructed and discovered through learner's experience is the perception of ……. theory.

a) Constructivist

b) Behaviorist

c) Cognitivist

d) Contextualist

48. Following is an example of a set except.

a) All toys of Ali

b) All toys of Nariman

c) All friends of Ali and NAriman

d) Multiplication of Ali and Nariman's toys with their friends

49. Jigsaw encourages ….. and active leaning.

a) Cooperation

b) Isolation

c) Self learning

d) Separate reading

50. When information is presented to the students through visualization it is stored in:

a) Long term memory

b) Short term memory

c) Conscious memory

d) Sensory memory

51. Which theory assumes that a learner is essentially passive, responding to environmental stimuli?

a) Behaviorism

b) Cognitivism

c) Constructivism

d) Information processing

52. One will have more chances of being successful as a teacher, if

a) He belongs to the family of teachers

b) He is trained in teaching

c) He has ethical values and good character

d) He can organize his teaching material systematically and conveys the same effectively

53. Visual system has a ….. Power

a) Modeling
b) Unusual
c) Imperfect
d) Irregular

54. The time consumed in …….. Learning is worthwhile.
a) Lecture
b) Book
c) Inquiry
d) Discovery

55. What should be the aim of a teacher when he or she enters a classroom?
a) Read
b) Discuss
c) Role play
d) Bring change

56. Teachers usually avoid hypothesis testing in classroom because it is …….
a) Time consuming
b) Difficult
c) Impossible
d) Not impossible

57. Which type of the following people could not afford the higher technology?
a) Consumer
b) Non consumer
c) Vendor
d) None of the above

58. An outstanding lecture must comprises of the following except:
a) Interesting
b) Engaging
c) Informative
d) Boring

59. Discovery based learning has a direct link with the theory of …..
a) Constructivism
b) Cognitivism
c) Behaviorism

d) Connectivism

60. Thinking is driven by …..

a) Answer

b) Question

c) Assessment

d) Test

61. The teacher must keep in mind when posing a problem all points except:

a) The learner should appreciate the problem and could identify the input and output .

b) Move from complex to simple

c) Move from simple to complex

d) Take into account the prior knowledge of students

62. The rate of rate of displacement is.

a) Acceleration

b) Speed

c) Momentum

d) Velocity

63. Non-intuitive problems need ……

a) Reflection

b) Guidance

c) Visualization

d) Storytelling

64. Teacher is a … word.

a) Latin

b) Germanic

c) Spanish

d) Italian

65. The concept of sets was included first time in 1967 in ….. Syllabus.

a) Fsc

b) Bsc

c) Ba

d) Matric

66. …….. symbolizes teachers and teaching.

a) Apple

b) Banana

c) Mango
d) Grapes

67. Meaningful learning comes from contradiction>resolution> and ……..?

a) Understanding

b) Evaluating
c) Interpreting
d) Observing

68. Which option from the following is related to the subject matter?

a) Technology
b) Content knowledge
c) Pedagogy
d) Design

69. Addition of two sets is find out by applying the

a) Union
b) Intersection
c) Taking subset
d) Making proper set

70. If we present the information to students through visualization, where the information will be stored?

a) Sensory register
b) Long term memory
c) Working memory
d) Short term memory

71. The degree of success a teacher has in using technology for instruction is mostly dependent on:

a) Teacher method
b) Student growth
c) The teacher's ability
d) Teacher's experience

72. Set is defined as:

a) Any well-defined collection or list of districts objects
b) Consists of some elements of another set
c) Two or more type of elements is present in it
d) None of the above

73. Jigsaw method is a --------- learning technique.

a) Direct
b) Cooperative
c) Discovery
d) Inquiry

74. The problem-based learning model has all of the following features except
a) Authentic investigation
b) Collaboration
c) Highly structured learning environment
d) Production of artifacts

75. An explanation of why something occur or how it occurs is called:
a) Theory
b) Concept
c) System
d) Scheme

76. Discovery-based learning differs from the presentation method because it has a focus on-------
a) presenting ideas
b) Demonstrating skills
c) Presenting concepts
d) Facilitating investigations

77. Asking the right question is the fundamental to the process of -------
a) Testing
b) assessing
c) Teaching
d) Learning

78. -------- Technology is mostly used by non-consumers.
a) Modern
b) Disruptive
c) Lower level
d) Higher level

79. In---------- classroom the carefully crafted question are generated by both teachers and students.
a) Direct
b) Indirect

c) Lecture based

d) Curious

80. Discovery based learning has a direct link with the theory of ----------

a) Constructivism

b) Cognitivism

c) Behaviorism

d) Connectivism

81. Which of the following concept was given by Marvin winsky in his book the emotion machine?

a) Problem solving

b) CS analyzing

c) Computer programming

d) Artificial intelligence

82. Discovery based learning is --------

a) Student centered

b) Teacher centered

c) Group focused

d) School centered

83. A better understanding of brain function will promote a ---------- approach to learning.

a) Flexible

b) Inflexible

c) Rigid

d) Resistant

84. Which of the following is computer hardware?

a) Mouse pad

b) MS office

c) Computer desk

d) Processor

85. Teachers are closely associated with the ------- process.

a) Study

b) Learning

c) Evaluating

d) Observing

86. Which of the following expectations students have from group learning

a) To get appreciation from the group
b) To distribute the work equally
c) To ignore individual viewpoint
d) To attract isolated student towards the group

87. What type of students ability is assessed by the following question: what is CPU
a) Cramming
b) Analyzing
c) Synthesizing
d) Evaluating

88. ---------- is a situation where disagreement or discord ultimately gives rise to better ideas or outcomes.
a) Creative tension
b) Asking question
c) Hypothesis testing
d) None of the above

89. When preparing for problem-based instruction the teacher would be least concerned with
a) Communicating goals clearly
b) Preparing answers to the problem situation
c) Designing interesting and appropriate problem solutions
d) Planning logistics

90. The statements of learning achievements are called as
a) Learning assessment
b) Learning objectives
c) Learning methodology
d) Learning outcome

91. The aim of teacher is
a) To help student get through in examination
b) To make student disciplined
c) To develop the ability of the students
d) To develop social behavior among the student

92. ---------- is an educational philosophy which holds that learners ultimately construct their own knowledge
a) Constructivism

b) Cognitivist
c) Behaviorism
d) Connectives

93. Meaningful learning comes from Contradiction>Resolution and ----------

--

a) Understanding
b) Evaluation
c) Interpreting
d) Observing

Q.1 The intersection between _____ and technological knowledge provides guide for effective teaching.

- Pedagogical
- Factual
- Procedural
- Technical

Q no.2 Pedagogy is a _____ and it requires some inputs and outputs

- Design
- Process
- Knowledge
- Technique

Q no.3 There ____ are stages of Polys method

- Two
- Three
- Four
- Five

Q no.4 learning styles

- Are unimportant compared to teaching styles
- Are predominately to U.S students
- Reveal significant and pervasive genetic difference between girls and boys Are unique to the individual

Q no.5 Logic and deduction are included in

- Mental process
- Emotional process
- Conceptual Process
- Behaviorism

Q no.6 An explanation for why something occur or how it occurs is called

- Theory
- Concept
- System
- Scheme

Q no.7 The degree of success a teacher has in using technology for instruction is mostly dependent on

- Teaching method Student growth
- The teacher's ability
- Teacher's experience

Q no.8 Learning through positive reinforcement is an example of _____ technique

- Behaviorist
- Constructivist
- Cognitivist
- Contextual

Q no.9 What should be the aim of a teacher when he or she enter in a classroom

- Read
- Discuss
- Role play
- Bring change

Q no. 10 Discovery based learning is

- Student centered
- Teacher centered
- Group focused
- School centered

Q no. 11 Following is an example of set except

- All toys of Ali
- All toys of Noriman
- All friend of Ali and Nariman
- Multipication of Ali and Nariman toys with their friends

Q no. 12 which of the following expectations students have from the group

- To get appreciation from the group
- To distribute the work equally
- To ignore individual view point
- To attract isolated students towards group

Q no. 13 the statements of learning achievements are called as

- Learning assessment
- Learning objectives
- Learning methodology
- Learning outcome

Q no. 14 Kinesthetic learners learns best

- By doing
- By hearing
- By using text and watching videos
- In calm quit surroundings

Q no. 15 what should a teacher do to investigate the level of students understanding at the end of class lesson

- Reflect
- Pose a question,
- Reproduce the lecture

- None of the above

Q no. 16 Discover based learning differs from the presentation method because it has a focus on

- Presenting ideas
- Demonstrating skills
- Presenting concepts
- Facilitating investigations

Q no. 17 Which of the following is an art of teaching

- Content
- Pedagogy
- Technology
- Assessment

From the following options which helps a person to make sense of world

- Technology
- Prior knowledge
- Facts
- Communication

The problem based learning model has all the following features except

- Authentic investigation
- Collaboration
- Highly structured learning environment
- Production of artifacts

What type of students ability is assessed by the following question: what is CPU

- Cramming
- Analyzing
- Synthesizing
- Evaluating

The aim of teacher is

- To help student get through in examination
- To make student disciplined
- To develop the ability of the students
- To develop social behavior among the student

The average velocity and the instantaneous velocity of an object will be same if

- The object speed is constant
- The object acceleration is zero
- The object velocity is always positive
- They are never the same

Hard ware of a computer can be defined as

- The machine and program making up computer
- The parts of a computer which you can touch
- Operating system
- Program needed to run computer

_____ is an educational philosophy which holds that learners ultimately construct their own knowledge

- Constructivism
- Cognitivist
- Behaviorism
- Connectives

The purpose of teaching is to facilitate

- Acting
- Practicing
- Learning
- Teaching

One will have more chances of being successful as a teacher if

- He belongs to the family of teachers
- He is trained in teaching
- He has ethical values and manners

- He can organize his teaching material systematically and discover the same systematically

Addition of two sets is found by applying the

- Union
- Intersection
- Taking subset
- Making proper set

What is historical focus of teacher education

- Practice experiences
- Content knowledge
- Reflective practices
- Pedagogical knowledge

A well defined collection of distinct object is called

- Set
- Union
- Sequence
- None of the above

Successful educational practices evolve from the application of ___ method

- Analog
- Scientific
- Virtual
- Technical

The lecture will communicated more affectively if teacher

- Read the prepared notes
- Prepare the good notes in advance and use them as guide
- Engage students in immediate discussion
- Quote example from other teaching sessions / lectures and engage students in immediate discussions

The purpose of teaching is to facilitate

- Acting
- Practicing
- Teaching
- Learning

When preparing for problem based instruction the teacher would least conceraned with

- Communicating goals clearly
- Preparing answers to the problem situation
- Designing interesting and appropriate problem solutions
- Planning logistics

It is important to test the _____ of the students

- Prior knowledge
- Factual knowledge
- Conceptual knowledge
- Technological knowledge

Kipling was born in

- Bombay
- America
- England
- Delhi

Which option of the following is related to the subject matter

- Technology
- Content knowledge
- Pedagogy
- Design

The velocity function is all of the following except is

- A function of time

- The derivative of the position function
- A function which gives the velocity of an object at any point in time
- None of the above

Computer system consist of

- Hardware and software
- Input and output devices
- Processor and backing storage
- Monitor, mouse, keyboard, processor

What is the most important thing for the student learning

- Drill
- Wrote memorization
- Motivation
- understanding

Lesson #1

1. When a teacher enters a classroom, his aim is to **teach** the students
2. A teacher of calculus he may want to teach differentiation and integration.
3. At first part, there is only **rote** learning.
4. There is only **rote** learning.Second is about **understanding** and at third level the brain's **logic level** starts working
5. achild can generate meanings through the **concept.**
6. Common excuses for the limited use of technology to support instruction includeshortage of computers, lack of **computer skill and computer intimidation**
7. .**Pedagogy-based** training begins byhelping teachers understand the role of learning theory in the design and function of class activitiesand in the selection and use of instructional technologies.
8. The relationship between **instructional technology** and **pedagogical concepts** is considered witha view of assisting teachers to recognize the impact of such a relationship in an educational inquiry.
9. **Technology integration** is complex and is made up of processes of **interconnected activities.**
10. It's hard to get students to learn basic anything unless they are motivated to learn.
11. **Prior** knowledge is important because it helps a person make sense of the world.
12. 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,
13. A teacher must **plan** properly before teaching any topic.
14. The method and practice of teaching, especially as an academic subject or **theoretical** concept
15. .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.**

16. A **pedagogical** tool is anything that a person uses to **learn or teach**
17. 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**.
18. **pedagogical tools** include items such as worksheets, textbooks, handouts and hands-onmodels
19. Pedagogy also includes **assessment,context**, priorknowledge, classroom environment, curriculum,
20. **In Technology** the students and teachers using toolssuch as websites or mobile device applications
21. **Pedagogy** is a learning process
22. **Knowledge** continues to reshape itself
23. a teacher must try to analyze the **effectiveness** of the tools used as well
24. The learned men of ancient times, by default became the **teachers**
25. **Priests** and prophets taughtchildren of the wealthy and noble, the skills to take up their roles as leaders and businessmen.
26. Teacher a**ppreciation** was a widespread feeling, and respect for teachers was proportional to their **high value** in those societies.
27. The quality of the class will depend solely on the quality of the teacher and not the presence of **technology.**
28. During the primitive times, all education was **informal**
29. the teachers should develop strategies to **motivate** students to keep them focused as the instruction progresses
30. teachers should be able to engage students in an **exploratory learning** experience

lesson # 2

1. Teacher education has historically focused on **content** knowledge
2. In other words, effective teachers utilize both **content knowledge** and **pedagogical knowledge**,
3. The intersection betweentechnological, pedagogical, and content knowledge provides guide for **effective** teaching
4. **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.

5. Learning outcomes can be measured to assure the amount of learning that takes place. These can bemeasured through **examination or tests**.
6. Learning outcomes are statements of a **learning achievement**
7. . Instructional or educational technology should be **"integral to teaching practice**" and not viewed as an add-on to teaching
8. **Pedagogical content** knowledge is a type of knowledge that is unique to teachers, and is based on themanner in which teachers relate their pedagogical knowledge totheir subject matter knowledge
9. Pedagogical content knowledge is **the teaching** strategies

Lesson # 3

1. **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
2. **Rudyard Kipling** (1865-1936) was born **in Bombay,**
3. His literary career began with ***Departmental Ditties***(1886),
4. Subsequently**Rudyard Kipling**became **chiefly** known as a **writer** of short stories.
5. Learning theories play a vital role in identifying and solving the **problems** of learning.
6. A **theory** is an explanation for why something occurs or how it occurs.
7. **theory** is generatedby a question
8. A theory of learning aims tohelp us to how people learn. Many theories of learning were generated in the **20th**century**Understand.**
9. **Behaviorism** assumes that a learner is essentially passive, responding to environmental stimuli.
10. Behavior is shaped by **positive and negative** reinforcement.
11. **Positive** reinforcement is the application of a **stimulus**
12. **Negative reinforcement** is the withdrawal of a stimulus.

13. **Behaviorism** is a precursor to cognitive learning.
14. Learning through positive reinforcement is an example of a **behaviorist** technique
15. **Constructivist** approaches can also be used in online learning. For example, tools such as discussion forums, wikis and blogs
16. **Constructivism** is a philosophy of learning founded on the premise that, by reflecting on our experiences,
17. Learning is an **active process**
18. Knowledge is constructed, rather than innate, or **passively absorbed**
19. Knowledge is **invented** not discovered
20. **Meaningful learning:**
    Contradiction-> Resolution -> Understanding
21. **Contextual knowledge** is the application of knowledge in real life context.

Lesson # 4

1. **Pedagogy** is the art of teaching/education. Pedagogical knowledge is knowing how to impart thatinformation to your students in the most effective method
2. pedagogy is learned through **experience**
3. **Abstrac**tion is a complex state of understanding.
4. A teacher must take the students from known tounknown**, simpler to complex.**
5. **Kinematics:** "The branch of mechanics concerned with the motion of objects without reference tothe forces that cause the motion." It involves the concepts of velocity, displacement andacceleration.
6. Physics is not a study of equations; it is a studyof **fundamental principles.**

Lecture No 5th

1:- When Quaid e Azam was once quoted saying that"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". In sep26, 1947.

2:- Newton is basically talking about priorknowledge.

3:- If we provide prior knowledge to somebody or try to build new knowledge on that then new things can be discoveredeasily and new things can be understoodeasily.

4:- Which author said that quotation "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." WilliamMoab.

5:- Thebrance of mechanics involves the concepts of velocity, displacementand acceleration.

6:- While learning to solve kinematics, students usually have far too many equationsbouncing around inside their heads.

7:- In kinematics physics is not a study of equations; it is a study of fundamental principle.

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

Learning objectives of FSc book	Learning objectives of O level book
Rote learning	Understanding
No focus on interpretations	Focus on interpretation
Graphs only for learning	Ploting and interpreting of graph
Recalling of equations	Understanding and applying theequation

9:- 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	Concept of acceleration
Displacement and velocity covered in 17 pages	Displacement and velocity covered in 26 pages

10:- Sky diving is an adrenalin filled extreme sportwhich has its own dangers.

11:- Nonetheless, in the book of O Levels, they have shown things analyticallyand graphically, though not numerically.

Lesson 06

Edu654

DISCOVERY BASED LEARNING

By ZeeshanNadeem

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

Make use of knowledge.

Integrate it with new knowledge.

Both A and B

None of these

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 meaning from an interaction between their **experiences** and their **ideas.**

The **constructivist** approach emphasizes the use of **pre-existing** knowledge

Discovery based learning is a method to achieve **constructivist** learning.

Example: example of discovery Base learning

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 realworld 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.

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

.**Bothe A and B**

Only A

• 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

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.

Teaching Method

- Useful
- More likely to be remembered

Stating Conclusion

- Trivial

- Likely to 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 subtype 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.

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

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 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.

End

From: ZeeshanNadeem.

Creat by Maryam Toseef

Lecture No 7th

1:- Active scientific inquiry is very importantand units developing this skill should start at the 6thand 7thlevel.

2:- They learn how to plugand chugthe formulas but do not understandthe concept behind arriving to the solution.

3:- Curriculum is very important.

4:-If your learning outcomes are related to memorizingthen it is not discoverybased learning.

5:- The question is of appropriate curriculumand appropriate pedagogyand the effectiveness of discovery learning is required in Computersciencediscipline at school level.

6:- Computer Science is not just programmingbut the whole set of concepts and processes that assist in the development of computer systems.

7:- Computers and algorithmic processes are important for survivaland for thriving in a modern world.

8:- In ACM they have discussed the best practices; the one best practice for teaching programming is

"pair programming".

9:- The new paradigm of learning which we took from the computer science are solvingalgorithmand providing instructionsand feedback.

10:- It depends on the teacher to introduce the teamworkor groupcomputationor otherstrategies.

11:- Algorithmand graphtheorydo not require computers for learning, you can even teach them without a computer.

12:- What are the recommendation of ACM?

• Problem solving skills

• Fundamentals of CS

• CS as analysis and design

13:- in Pakistan; Concept focus is far less than the focus on skillsand terminology.

Lesson 08by NAINA

RECOMMENDATIONS ABOUT CS EDUCATION IN HIGH SCHOOL & COLLEGE LEVEL IN PAKISTAN

1-When we see computers, the first thing we visualize is its hardware .

2- **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.

Computer software and programming:

Computer software and programming first & second aspects are Operating systems

& Application programming

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

4-**theory and algorithms** is neglected in most of American Universities; it includes graph theory, algorithms and discrete math.

5- 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.

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

"Knowledge is represented in different ways

7- by Marvin Winsky, "Knowledge is represented in different ways

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

8- Our brain is programmed to tackle instruction. According to Minsky.

9- 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?

10- 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?

11- 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

12- good quality of thought. Non psychlogists did this by trail and error.

13-.Minsky discover it through experimentation that these 6 are the basic principles to define human thinking.

14- Minsky discover says that

- 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

15-**Areas in the field of CS:**

- Thinking, problem solving, algorithms
- Programming
- Hardware

Sub module:

16-In sub modulewe discover about computer organization and hardware.

17- 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"

Story telling:

18- Storytelling is a mega framework that develops in very young children for holding information.
19-The sequence of a story is logical or quasi logical.
20- Provide them good and attractive building blocks which trigger their natural sense of play and experimentation.

Challenges as an Instructor

21- **Challenges as an Instructor** in following steps:

How to make the building blocks

•How can we create excitement, interest and motivation for discovery among students

How to follow the ACMs recommendations

Lesson 09

HOW SETS CAN BE TAUGHT THROUGH DISCOVERY BASED LEARNING (DBL)

1-Sets and discrete objects were included for the first time in the F.Sc. syllabus in 1967.

2-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.

3-Most of the students are not going to become mathematicians, only 1% of the whole class.

4-students in a way that they can use it effectively as an applied mathematics tool in any field of life.

5-Discrete mathematics does not involve calculus and analytical geometry.

6-Discrete mathematics involve or 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:**

7- A set of people who wrote pedagogically good books on mathematics, is a small set.
8-A set of concepts difficult to understand in graph theory and group theory
9-A set of instructors friendly to new teaching ideas'
10- A set ofwell-defined collection or list of distinct objects.

Visualization of sets:

11- The things in set which are visible is called Visualization of sets.
13-12- Natural numbers example 0, 1, 2, 3, 4, 5 ……..
14-Even Numbers example: 0, 2, 4, 6, 8 ……
15-Odd Numbers example: 1, 3, 5, 7, 9 ……..

Subset:

16- A set that consists of some elements of another set is called a subset of that set.

17-if B is a subset of A, then every member of set B is also a member of set A.

18- This knowledge of sets is our prior knowledge which helps us to understand the concept clearly.

19- the set of even numbers a proper subset of natural numbers.

20- the set of odd numbers a proper subset of natural numbers.

21- - If we put together odd and even numbers, would we get natural numbers.

22- we can quantify even and odd numbers.

23- We Can't compared with each other because it is the proper subset.

Operations on sets:

24- **Intuitive & Non- intuitive concepts operation on sets.**
25-the students clearly that union means adding both the sets.
26- Multiplication of two sets in not intuitive.

27- There is always a relationship between sets and subsets of the two original multiplied sets.

24- The students often surprise us with what they already know or half-know.

25- By using the 'discovery technique' we learn more about their knowledge and abilities eliciting information.

26- Math curriculum guides must require the learning of standard algorithms, and textbooks must contain clear, systematic instructions as to their use.

Lesson 10

HOW THE HUMAN BRAIN WORKS, THE BIOLOGY OF BRAIN AS STUDIES BY A NEUROLOGIST

Recap:

1-duck float on water because there is a special uropygial gland near the tail.

2- Professor Zull, Director in center for innovation in teaching in education.

3- These two networks became physically connected neuronal networks also included proteins and biochemistry.

4-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.

5-Educators can use knowledge about the brain to enhance pedagogical techniques.

6-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.

7-The author says that brain is designed through evolution and in this way it can learn through experience.

8-Learning means changing the brain.

9-Teaching is the art of changing the brain in a natural fashion.

10-Neurons in the brain are similar as the connections of concepts in the brain.

11-Biological understanding of learning is very important

12-Learners construct their own understanding by building on prior knowledgeThis is no longer a theory of learning.

13-Connections in the neuron network ⟹ connections between concepts.

14-Knowledge cannot be transferred. It can only be constructed and discovered through a learner's personal experience.

15-A great deal of brain is dedicated to physical relationships in space. It has a great capacity to create and remember images.

16-There are three things, prior knowledge, image/ visualization, and connections.

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

18-The single most important factor in learning is the existing network of neurons in the learner's brain.

19-When two knowledge states are activated together again and again they build connections among themselves.

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

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

22-A well-defined curriculum including written course textbooks are requirement for a mandatory, formal CS teaching license.

23-In Israel, there is a national center; this national center is considered as a professional home for all Israeli computer science teachers.

Posing a problem:

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

25-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

26-High tolerance for errors, failures and exhibit patience and dedication to solve the problem.

27-Don’t jump to the solution; rather master the method to solve the problem.

28-The time consumed in discovery learning is worthwhile.
29-Allow students to construct their knowledge through DBL
30-Build more and more connections in their minds.

Lesson 11

THE ROLE OF IMAGES & PICTURES IN LEARNING

1-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.

2-the writer Prof. Zull says that:

Better understanding of brain function will promote a more flexible and varied approach to learning.

3-Educator s can use knowledge about the brain to enhance pedagogical techniques.

4-Teaching is the art of changing the brain in a natural fashion

5-Prof. Zull also says that:

our brain is basically a seeing brain. It means that “A picture is worth a thousand words.”

6-Physical objects in the world contain conceptual relationships and so then do the neural networks of our brain.

7-Researchers in this field have even suggested that there is no upper limit to the number of pictures that the brain can store.

8-studies suggested the astounding result that the human brain can search for more than 50,000 images per second in long term memory.

9-According to Harvard calculus, every concept should be presented in:

- Graphically
- Numerically
- Verbally
- Analytically

10-Newton's laws include verbal explanation, graphical representation, numerical questions to verify.

11-. Exponents give dramatic images of growth if we make their graphs, attrition, explosion and fading away.

12-use visual aids to help students in DBL.

13-The word teacher is derived from the word teacan, which meant 'to show'.

14-Teacan is a Germanic word, when it is changed to Latin it becomes'teacher'.

15-The book of "Conceptual Physics" is taught at High school in United States, almost 2/3 of the teachers recommend this book.

16-"Conceptual Physics"is one of the most popular books in United States. Since defining this course 30 years ago.

17-Paul Hawirtts'best selling book continues to be the benchmark book that two thirds of professors use and by which all others are judged.

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

19-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 .

20-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

21-Basically reflection is searching for connections between different concept, events or whatever .

22-Reflection is the key to create knowledge.

Abdul Basit

Edu 654
Chapter 12

How many steps to solve problems

Four

1. Strategy level
2. Tactics level
3. Tools
4. Reflection

The author of "The Art and Craft of Problem Solving is

Paul Zeitz

Our brain try to find a

Pattern

Lesson # 13BY M.Ahmadsaadiq

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.

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.

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 HolgerHyden 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

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." TalmaLeviatan
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 greatadvantages 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.

VU 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-dependentprobability/old_prob_videos/v/probability--part-1

Lecture # 17

MCQ

Jiyaaa Islam

1: _____types of thinking activity, effective and ineffective.

Two

2: _____thinking doesn't clarify anything, doesn't raise questions, and causes no change or strengthening to world view

Ineffective

3: _____thinking does make changes to world view,belief, opinion, attitude, behaviour/s, skill/s, understanding/s and knowledge.

Effective

4: Thinking is _____to learning

Central

5: No learning without _____

thinking.

6: Superficial questions equal _____ understanding.

superficial

7: Questions of purpose force us to define our _____

task.

8: Questions define tasks, _____and delineate issues.

express problems

9: _____is a process that modifies or strengthens world views, beliefs, opinions, attitudes,

behaviours, skills, understanding, and knowledge.

Learning

10: _____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

11: Thinking and learning have the same outcomes, so have to be very _____

Close

12: Thinking and learning have the _____outcomes

Same

13: _____someone as a learner won't happen unless we empower them as thinkers.

Empowering

14: learning and thinking _____ be separated

can't

15: the questions they do have tend tobe superficial and _____

ill-informed.

Lesson 01

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 aboutteaching 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.

Lesson 02

THE BENEFITS, USES & IMPORTANCE OF THE COURSE IN TEACHING & 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.

Lesson 03

HOW WILL WE USE & ACHIEVE BENEFITS OF PEDAGOGY IN TEACHING & 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.

Lesson 04

APPLICATION OF PEDAGOGICAL TOOLS & 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.

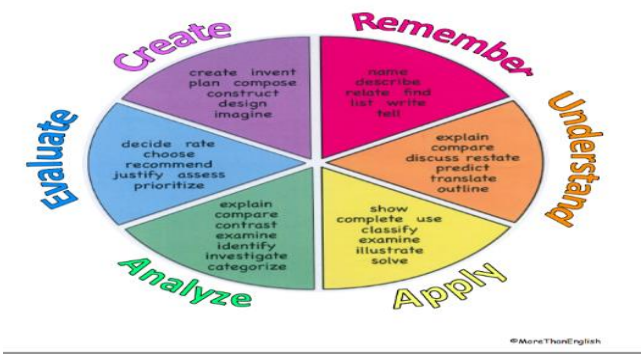
Review of the previous lessons:

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 knowledgeknows 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.

Lesson05

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 Kinematics 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 mapsare 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

Lesson06

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 meaning from 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 **- More likely to be remembered**	**-** Trivial - 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. Polyawas 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.

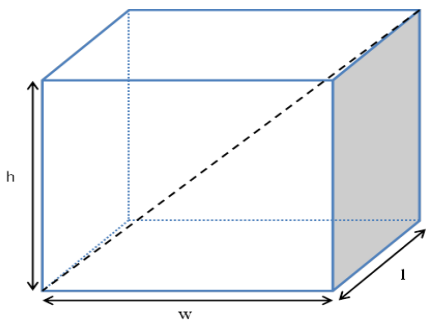
Lesson07

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.

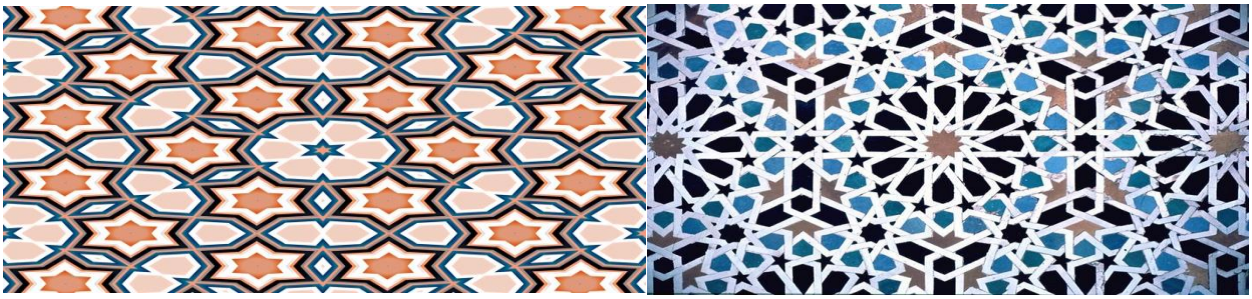
What is CS?

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.

Lesson 08

RECOMMENDATIONS ABOUT CS EDUCATION IN HIGH SCHOOL & 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 Abstractto 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

Lesson 09

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 7th 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,

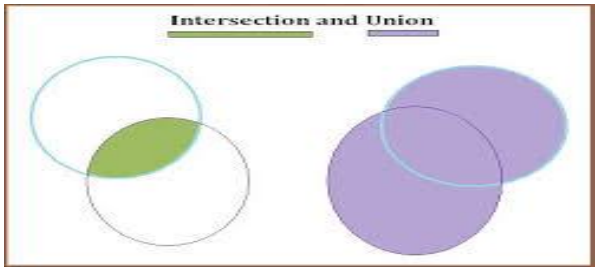
- Is the set of even numbers a proper subset of natural numbers? yes
- Is the set of odd numbers a proper subset of natural numbers? yes
- If we put together odd and even numbers, would we get natural numbers? yes
- Can we quantify even and odd numbers? yes
- Can they be compared with each other? No,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

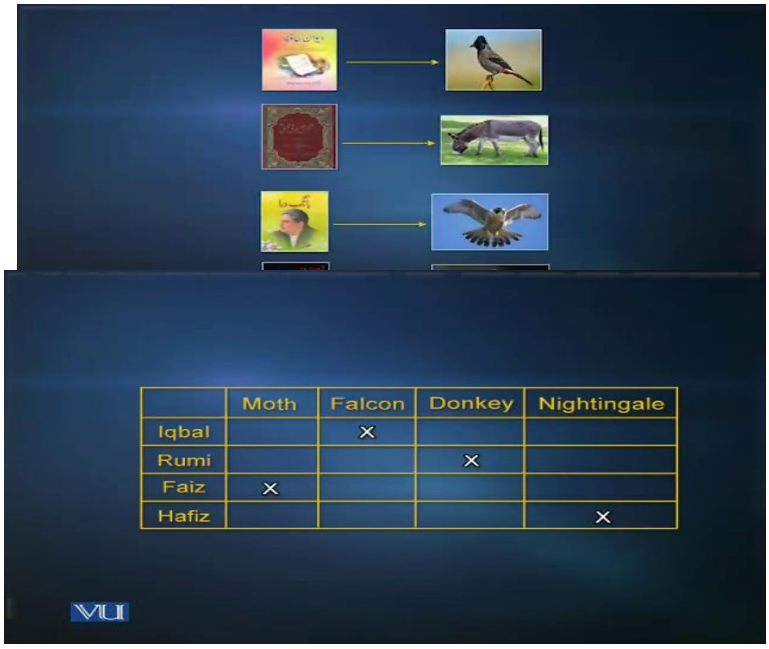
What is the product of set A and set B?

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.

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.

Lesson 10

HOW THE HUMAN BRAIN WORKS, THE BIOLOGY OF BRAIN AS STUDIES BY A NEUROLOGIST

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.

Lesson 11

THE ROLE OF IMAGES & 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.

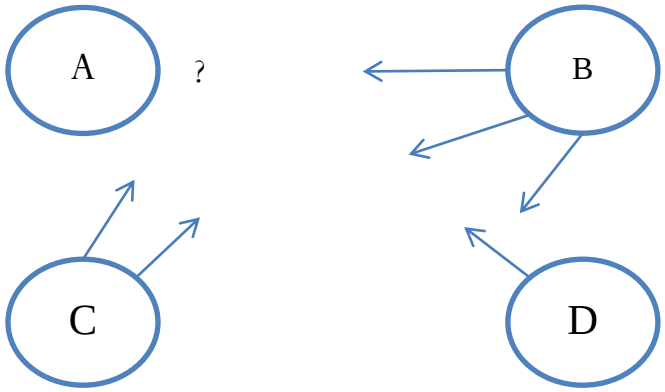
Aslam is represented by A in the below picture and salma's friends with B, C and D.

A B C D

Salma asked her friends with how many people they shake hand today. Her friends 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

Lesson 12

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:

5. Strategy level
6. Tactics level
7. Tools
8. 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 x 2 x 3 x 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 x 3 x 4 x 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 x 4 x 5 x 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 x 2 x 3 x 4 = 24

2 x 3 x 4 x 5 = 120

3 x 4 x 5 x 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 x 2 x 3 x 4 = 24

$24+1 = X^2$

where x is a natural number OR

$X^2 -1 = 24$ 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.

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

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

Lesson 13

TEACHING PROBABILITY - 1

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."

TalmaLeviatan

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

Lesson 14

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

Lesson 15

TEACHING PROBABILITY - 2

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

- **<u>Tutorial: The Probability of Understanding Probability with(out) pedagogy & Technology</u>**
- 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.

Lesson 16

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.

Lesson 17

THE RELATIONSHIP BETWEEN THINKING & 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.

Lesson 18

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. 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.

Lesson 19

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.

Lesson 20

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 Calculasare, 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

Lesson 21

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.

Lesson 22

IMPORTANCE OF ASKING QUESTIONS - 1

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.