Role Of Innovative Teaching Methodologies, Superlative Audiovisuals For Disseminating Knowledge To Students & Futuristic Learning Pathways In Science, Other Disciplines

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Abstract: Today the world is facing a serious problem of Corona virus pandemic which has impacted Education Systems across the globe. This situation created a need to develop effective, innovative teaching methodology incorporated with good quality educational videos for the purpose of disseminating knowledge to students. Audiovisual course curriculum needed to structured, innovative, incorporated with lots of introductory videos, Question based study, Animations and pictorial representations, Experimental Audiovisuals, Analogies, Application Videos, Problem solving approach, live Experiments, analogies to create interest, share & empower knowledge among student community is discussed. Innovative teaching methodology with Animated Educational videos have become an important content delivery tool in many flipped, blended online courses. A brief picture of concerns of students, need to incorporate structured innovative teaching methodology, overall digital strategy to meet futuristic educational goals is portrayed in the paper.

Key words: Innovative Teaching Methodology; Introductory Videos; Scientific Methodology; Analogies; Question Based Study; Live Experiments; Problem Solving Methodology; Application Based Videos; Disseminating Knowledge; Futuristic Educational Goals;

INTRODUCTION

Today the world is facing a serious problem of Corona virus pandemic and a serious challenge arises as to how Knowledge has to be shared, imparted among students in this precarious scenario. Post Covid pandemic, the role Audiovisuals has gained prominence, become an important integral part of traditional courses in education system and serves as a cornerstone of many blended/ flipped, blended online courses. What, then, are the principles that allow instructors to choose or develop videos that are effective in moving students toward the desired learning outcomes? Structured & Effective Audiovisual online course with the inclusion of innovative learning tools offers the best information delivery mechanism. Innovative Methodology incorporated with animated audiovisuals helps instructors to maximize video’s utility in classrooms for teaching Science disciplines like Chemistry, Physics and Biology as it would: Reduce cognitive load, increases Student engagement, effectively imparts knowledge, enables active learning experience, acts as an effective information delivery mechanism among all teaching and student communities. Education is an important pillar, playing significant role in countries development. The need to develop quality content via audiovisuals not only imparts knowledge to students in right direction but also aids in empowering quality education.

The paper is pure reflection of authors innovative teaching methodology adopted in Audiovisual Project entitled “Audiovisual Representation of Chemistry (AVC)”, developed after 10 years continuous hard work and dedicated research on teaching methodologies. Audio Visual Representation of Chemistry (AVC) is a place to learn basic concepts in chemistry. The short videos are useful for students aspiring strong foundations in Chemistry. The Top Quality audiovisuals provide in depth subject using Experiments, Introductions, Animations, Pictorial representations, Logical reasoning and Analogies. Passion to teach and share our knowledge in the field of Chemistry has motivated us to develop good quality videos. We believe that they would have a huge impact on learning process of students, as well as aid in enhancing teaching methodologies. Audio Visual Representation of Chemistry(AVC) target audience are 10+ 2 students of India, IIT JEE, NEET aspirants, K12 students of US/UK and general learners in search of deep insights into basics of chemistry. AVC has about 900 videos covering various sub-topics of Chemistry, viz., Organic Chemistry, Inorganic Chemistry and Physical Chemistry. Author has prepared Story Boards (1000), typed matter around 35000 odd slides in software, rendered Voice over’s (4000min), designed & developed videos with more than 35 hour run-time, organized into 38 chapters, after 10 years of continuous hard work and dedicated research on teaching methodologies.

I. Generally after delivery of lectures by educators, it is noticed that many students lack basic concepts of science discipline, unable to solve problems and fail in the application part. This lacuna in the student community asserts the need to develop an innovative animated audiovisual course, by taking chemistry discipline as an example.
Challenges faced by Educators – Steps involved in designing audiovisual curriculum using innovative teaching Methodology

1. Generating Students Interest: Owing to its dryness of certain topics like organic, physical, inorganic chemistry, educators feel difficulty in teaching and fail to create interest among students, in turn leading to boredom.

Role of Introductory Videos in Generating Interest & Social Responsibility: Each Chapter is provided with an Introductory Video – Introduction to a topic using real life examples creates interest among students and all learners. An effective introductory audiovisual is a video aimed at introducing any topic of any discipline. Introduction video could be designed by building a story using certain existing facts of related content, finally connecting with the chemistry topic.

Defence Mechanism in Millipede - https://www.youtube.com/watch?v=crQXa8_1xZE&t=1s
https://www.youtube.com/watch?v=OnRoU4U3UQ
Farmer raising tomato crop & Boron Family introduction;
https://www.youtube.com/watch?v=CK11VrcaaVY
Skydiving Experience & Alkyl Halides introduction;
Alcohol Consumption - Hangover - https://www.youtube.com/watch?v=h6fgcx6TdMo

Picture-1 portrays Defence Mechanism in Millipede, wherein Millipedes when attacked by a prey, releases compound called Mandelonitrile. This compound on undergoing chemical reaction results in products

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Hydrogen cyanide (HCN) & Benzaldehyde (C6H5-CHO), HCN being a poison kills the enemy. While benzaldehyde acts as an irritant, keeps away from the attack of ants. Defence Mechanism in Millipede introduces the topic Benzaldehyde – an organic compound. Videos should be meticulously designed to enable students to have a thrilling experience, significantly generate interest and aid in popularization of science/any discipline enabling effective information delivery mechanisms. Picture-2 refers to introduction of organic compound Ethanol by explaining hangover experience after alcohol consumption. Apart from introducing Ethanol – an alcohol, the video provides reason behind hangover, delivers a societal message as to how alcohol consumption is the cause of various accidents and health issues- Introductory videos should also serve as a medium to generate social responsibility, spreading awareness need to maintain good health among all sections of society, most importantly student community.

2. Creating curiosity among students - Question Based Study:

Audiovisual which begins by asking the question What, Why, How, ponders student's brain as to whether he/she knows the answer for question. Questions like - How is the human body related to chemistry? By answering that bones are made of Calcium Phosphate Ca3(PO4)2, Oxygen of air which we breathe helps to burn glucose, supplies energy to the body raises eyebrows & interest among students. Why can't 6 year old kids can’t swallow toothpaste? – Actually toothpastes contain mainly Sodium Fluorides, which when consumed cause damage to inner stomach lining, leads to cause vomiting. Such question based study creates interest and encourage students to pursue sciences. Educators should follow question based approach to enable students to think, introspect and in turn enhance answering capabilities. Definitions are used to explain or give sense of term - are difficult to memorize. By providing meaning of root word, definitions are easily explained. For example word – Electrophile is derived from 2 words Electro means electron, Phillic means loving, i.e. Electrophiles are substances which are electron loving.

Pictorial representations add value to Basic Definitions: To make definitions more attractive and understandable, definitions are associated with related pictorial representations. For instance word Thermodynamics is defined as the branch of science which deals with heat and forms of energy. Depicting a picture of a turbine motor enables students to get a basic idea of the definition, making learning process easier.
3. Role of Animations & Pictorial Representations:

To address student’s concept building issues, relevant Audiovisuals are incorporated with pictorial representations and animations. Audiovisuals should be crisp, matter specific, incorporated with simulated highlights and appropriate pauses.

Ex: Postulates of Kinetic Theory of Gases: This video explains Kinetic Molecular Theory of Gases - https://www.youtube.com/watch?v=B0uxOH4Bm2M

Practically the movement of tiny, invisible gas atoms, its collisions in the container is hard to realize in reality. To overcome atoms have been represented as balls with animated movement, while collisions are depicted by simulated highlights. Picture-2 refers to solid liquid equilibrium wherein water (H2O) is represented as the Space filling 3D model shown in closed ball filled structures. Model provides exact positioning of 3 atoms like Oxygen (O) & 2 Hydrogen’s(H). Animations, simulated highlights enable i) capture students attention, keep students engaged, experience visual impact ii) provide better conceptual clarity iii) 100% audio-visual synchronized videos aid in better learning process at molecular level.

i) Experimental Audiovisuals - Scientific methodology: Quality video content using scientific methodology includes 3 parameters: Experiment – Observation – Conclusion. Primarily the audiovisual should display actual experiments conducted by the scientists, to allow students to record observations, analyze data and finally draw conclusions with in-depth analysis & thoughtful animations. Experimental Audiovisuals helps students to gain knowledge, develop theory, in turn facilitates students to instill scientific temper and propels young minds towards innovations and inventions.

 Millikan’s Oil Drop Experiment - https://www.youtube.com/watch?v=DdLvJujDrAI

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Millikan’s Oil Drop Experiment Audiovisual displays experiment conducted by Robert Millikan, provides observations and enables students to calculate charge of electron using Physics and Mathematics. Visualizing invisible oil drop, how it attains negative charge on exposure to X-rays is possible with the help of in-depth animations and presents excellent conceptual clarity to students. Further, history of scientists, prevailing circumstances, incidents and scenarios which lead to the discoveries should be enumerated to students, to inspire them towards innovations & inventions

a) https://www.youtube.com/watch?v=iWlfz1JSes70&t=1s - Rutherford’s Experiment
b) https://www.youtube.com/watch?v=Ef3f3AWXMK&t=205s – Photoelectric effect
c) https://www.youtube.com/watch?v=J8mUFr0c5fU&t=246s – Stern Gerlach Experiment
d) https://www.youtube.com/watch?v=R1r9qT6rx9g – Chemical equilibrium Formation of HI
e) https://www.youtube.com/watch?v=w_46wiUy_xc – Bomb Calorimeter
f) https://www.youtube.com/watch?v=2hwsJGtNdBU – Properties of Cathode Rays
g) https://www.youtube.com/watch?v=BilG1GpeRvY – Vapour Pressure Experiment

Discovery of Insulin & Diabetes: Diabetes is a metabolic disorder effecting large population across the globe, is caused due to the deficiency of hormone Insulin. Insulin was discovered by scientist Banting (Orthopedician) under the supervision of Mac Leod-Physiologist; Charles Best is the chemist who refined pancreas extract insulin, while Collip purified Insulin. Revealing History aspects of inventions to students stimulates them think innovatively, directing them to inventions by following a multidisciplinary approach. Educators need to conduct simple experiments in class room using easily available things to create student interest.

ii) Home Scientific Experiments: Educators should explain phenomenon with simple experiments using simple available home items. This generates scientific approach among student community. For example Fruit Battery is made using a lemon, copper nails, light bulb and a wire. By inserting 2 nails into a lemon, separated by 2 inch distance, attached to a bulb via small wires, can make the bulb glow. This is because citric acid present in lemon contains charged ions, which acts as chemical energy. A Potential Energy difference exists between the lemon acid ions and Copper atoms present in nails. This helps the movement of charged lemon ions into copper nails i.e. chemical energy is converted into electric energy, flows through the wires acting as conductors, makes bulb to glow. Fruit Battery experiment works on Electrochemistry principle and may be applied to Daniel cells.

iii) Graphical & Comparative Study: Graphs are pictorial representations which enable to relate two variables using data. Graphs present small amounts or complicated data in simplified format, used to convey pronounced trends and reveals relations between variables. Boyles Isotherm is graph representing the variation of data in respect of two variables Pressure and Volume, recorded at constant temperature. Hyperbola graph obtained in the graph conveys that “Pressure of gas is inversely proportional to the Volume occupied by the gas”. A Comparative study is a method of comparing two or more concepts with the purpose of discovering something. Here in the

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h) https://www.youtube.com/watch?v=_Ns-gqnTzR8 – Adsorption & Absorption
i) https://www.youtube.com/watch?v=_xLiOvHYWE – Daniel Cell working
j) https://www.youtube.com/watch?v=BilG1GpeRvY – Vapour Pressure Experiment
k) https://www.youtube.com/watch?v=Ns-gqnTzR8 – Adsorption & Absorption
l) https://www.youtube.com/watch?v=fCNy1zrtNI0 – Tyndall Effect.
picture-2, different experimental studies were conducted using pressure gradient as a parameter to explain two different phenomenon diffusion and effusion. Picture- 3 refers to comparative study used to determine -How higher concentration of reactants would increase the rate of reaction in comparison to lower reactant concentration.

iv) Designing Thought Experiment: In an attempt to find the exact location of electrons in an atom, Werner Heisenberg has analyzed a thought experiment, which in reality is never possible. Heisenberg Uncertainty Principle - A Thought Experiment - https://www.youtube.com/watch?v=NxjW1GutYZg

Thought experiment proposed by Werner Heisenberg is realized with the help of an animated experiment depicting observations. By analyzing observations, Heisenberg’s Uncertainty hypothesis was proposed, which was instrumental in developing Quantum atomic theory and Existence of Orbital’s in an atom. Such audiovisual thought experiments shall instill scientific temper, enhance student’s innovative thinking abilities and enable Critical thinkers to revisit, rewind, rethink the concepts & stimulate Out of Box Thinking, in turn leads to inventions.

5. While explaining simple and complex topics, mere definition wouldn’t make student understanding better. Difficulty in student understanding arises in certain topics like Frequency of wave, state function in thermodynamics, SN2 mechanism in alkyl halides - Walden Inversion etc; Topics are hard to be understood and conceptualized as it requires imagination.

Analogies: Analogies are needed to clear complex topics. Introduction of analogies helped students to understand, memorize and conceptualize complex topics with ease.

- Frequency of wave - https://www.youtube.com/watch?v=zroD3-KaioQ:
  - Walden Inversion Analogy– https://www.youtube.com/watch?v=H-Znfsdnjb4&t=4s;
  - https://www.youtube.com/watch?v=OCas6IXZLM8 – Limiting reagent.

Frequency of wave: It is defined as the number of waves that pass through a fixed point in 1 second. This definition can be properly understood using following analogy. Consider a man sitting in a still pond. When a stone is dropped into a still pond, it creates a disturbance & this disturbance is propagated in water as waves. The number of waves that reaches the man sitting in still pond, which is considered as a fixed point in one second is called frequency of a wave. State functions like density, internal energy, entropy which depend on initial and final states are called state functions, these variables are path independent. State function is explained using mountain climbing altitude analogy. Here the mountain climber takes 2 different paths, one shorter...
and other longer path. The analogy proves that altitude which depends on initial (ground) and final states (top of mountain) and independent of path taken by the climber. Hence altitude is a state function.

6. Students inability in solving numerical problems after understanding concepts is a key concern. To address this problem innovative problem solving approach needed to be adopted. **Problem Solving Approach**: Numerical problems studded with many pictorial representations shall enhance problem solving abilities of students. Animated videos, problem solving videos using innovative tools like Wacom, Whiteboard & Screen recording software’s, enable students to understand numerical problems easily and develop problem solving approaches)

https://www.youtube.com/watch?v=PXXSIDF2DRE &t=113s -Dimensional Analysis is a method of conversion of a particular from one system( C.G.S) to another(S.I) System. The video helps to convert length in Centimeters to meters & enables learners how to buy a bike with particular wheel frame size ii) https://www.youtube.com/watch?v=ErAdIoumVKI – Activation energy. Educators need to encourage students to solve problem using different methodologies, to inculcate problem solving

7. After the topic is being explained by an educator in the classroom, many students could understand the concept, but fail in the application part. For example: How could we explain the breathing process in humans using chemical equilibrium? How does Tyndall effect help in watching a movie in a Cinema Hall?

**Application based Study**: To apply concepts in reality, application audiovisuals are needed.

Chemical Equilibrium – Breathing Process: https://www.youtube.com/watch?v=65LBCphHXw ; Breathing plays an important role in biological systems. Breathing is the process of inhalation and exhalation of air by lungs-Oxygen Gas (O2) of air is inhaled, while carbon dioxide (CO2) is expelled out. Does breathing process involve chemistry??? Yes definitely!

Let’s get into the details. When we breathe in, protein molecule called Hemoglobin (Hb) present in blood binds with oxygen gas (O2), undergoes chemical reaction and thereby forms a complex protein molecule Oxy-hemoglobin (HbO2). HbO2 formed in blood is transported to various tissues, under goes backward reaction reforming Hb & O2. O2 gas is utilized by organ cells, helps to generate energy called ATP (Adenosine triphosphate) required for carry out day to day activities. Movie watching-Tyndall Effect:
Projector light falling on dust particles present in air acts colloidal particles, undergoes scattering, scattered light on reaching eyes of audience, enables them to watch film - A Tyndall effect Phenomenon. Sailors throw cans punched with holes containing Calcium Phosphide (Ca₃P₂) into sea for signaling purpose. Here Ca₃P₂ reacts with water, forms explosive fire due to formation of Phosphine PH₃, which is used for giving location to other sailors through signaling.

Application oriented videos enable students to work on application part of all topics occurring in nature, enables to instill practical solution approaches. Breathing of Oxygen in Humans is the application of chemical equilibrium. Watching movie, twinkling of stars which are caused due to Tyndall Effect is presented effectively in audiovisual format. Application based videos help students to depict the importance of science, stimulating them to explore science in daily life instances.

8. How to relate explained topics to engage students in a class room?

In order to provide better understanding of explained topic in class rooms, class room should be used a virtual lab in explaining a topic. Imaginative explanations are required to explain invisible atoms present in matter. Consider a question “Why atoms combine to form compound? Generally atoms in their original state are highly energetic. It’s known that all high energy species say 2 Hydrogen atoms are highly energetic, combine with each other, loose energy and thereby forms stable Hydrogen molecule. Explaining such concept need a different case study approach, say two students A & B are involved. In case (1) student A is allowed to sit on chair. While in case 2 – student B is made jump on chair. Which student is stable student A or Student B? The answered we all know that student B jumping on chair is unstable, but how. Student B jumping up and down, is associated with motion has kinetic energy i.e. has high energy- Hence Student B is considered as unstable. While student A with no movement is associated with lesser energy, hence is considered as stable. Similar approach needed to applied where high energy atoms share electrons, form chemical bond & lead to formation of low energy and stable H₂ molecule.

Live Experiments: Live experiments audiovisual involving student and educators needed to be incorporated in curriculum.

Frequency of Wave Live Experiment - https://www.youtube.com/watch?v=4N7pYmPZACg

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After concept explanation by an educator, assessment has to be made whether the student understood the concept. Frequency of waves is understood by live experiments involving students and teachers in a class/school environment. In live experiment from school gate, both the Student and Teacher are asked to walk to school, which acts as fixed point within 20 seconds. Each step is considered as wave and number of steps required by both student & teacher to reach school destination in 20 seconds is called Frequency in live experiment terms. Found that teacher took 6 steps to reach destination by taking 6 steps, while student took 8 steps in 20 seconds. Student taking shorter steps has shorter wavelength or greater frequency, while teacher taking longer steps has longer wavelength and lesser frequency. In conclusion, student is said have greater frequency than teacher, which indicates that he is more energetic than teacher. In this direction live experiment videos enable students to understand, conceptualize concepts, memorize and apply them lifelong.

9. Solving numerical problems, failure to remember huge syllabus, failure to reflect the known subjects in exams are major key concerns of many students concerns.

Multiple Choice Questions & Mind Maps: Introduction of Multiple choice questions will assess students’ concept understanding. Mind maps are pictorial representations of a topic displayed in a single picture. Core topic name is centrally located in closed enclosure, while various subtopics of relevant topic are positioned at various locations of same page displayed in logical manner. Mind map is similar to brain acting as core topic, while neurons emanating from it act as sub topics. Actually mind maps needed to prepared, displayed in class rooms to help students to recollect entire chapter at one glance, and aid them to secure high grades.

10. Knowledge Sharing Social Media: Educators can share their knowledge in there are of expertise through knowledge sharing platforms like Quora also encourage students to post questions. Various Social media platforms like face book, linkedin, and instagram may be effectively used to share knowledge, comment experience students and academicians perspectives.

Certain Conclusions and Recommendations include:

- Audio visuals play an important role in teaching and learning aids in the Education Sector.
- Audio visuals should be short and of 6- 8 minute duration to enable effective engagement of target students.
• Communication skills courses should be included in curriculum as many students falter in interviews owing to their inability to express their perspectives. Educators should empower passion, empathy and innovative skills and let students know purpose of lives.

• Audiovisual innovative methodology may be used in various workshops to sensitize the educators in respect of innovative teaching methodology for the benefit of the student and education/research sector across the globe.

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