Advances in Science Education

Edited by

Hari Shankar Biswas
Sandeep Poddar
Amiya Bhaumik

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PREFACE

During the present pandemic situation, the whole world has been emphasized to accept the new-normal education system. The students and the teachers are not able to interact between themselves due to the lack of accessibility to a common school or academic building. They can access their studies only through online learning with the help of gadgets and internet. The whole learning system has been changed and the new modern learning system has been introduced to the whole world. This book on Advances in Science Education aims to increase the understanding of science and the construction of knowledge as well as to promote scientific literacy to become responsible citizenship. Science communication can be used to increase science-related knowledge for better description, prediction, explanation and understanding.

Education of science and technology is at the heart of the sustainable development. The first paper by Debarati Dey discusses about the Importance of Science Education to Achieve Sustainable Society.

The wildlife carrying capacity in many protected areas are significantly due to global warming, pollution, invasive species, and illegal hunting. The paper by Manish Kanti Biswas show that proper education and outreach programmes contribute to sustainable behaviour, promote public support for conservation, reduce vandalism and poaching practices in protected areas, and raise compliance with environmental regulations.

Nowadays, interdisciplinary education is achieving a myriad dimension of human skill opportunity to enhance future decision-making capability and design consciousness through multiple academic disciplines. Shamba Chatterjee and Sucheta Das in their reviewed article highlights interdisciplinary approaches that help us prepare graduates starting from their schooldays for upcoming leadership positions by addressing the multifaceted challenges today.

Science education has a prestigious career in the society of India. But after four decades of independence, the enthusiasm to provide science education has decreased and more involvement is in vocational field or non-basic science field. Hence, in the paper by Dr. Madhu Kumari Gupta drags the attention towards the problems faced by our country in progress of said field and also suggested some measures to mitigate the gap between study and research.

Over the years, many methods for action research have evolved, which focus on the actions taken by action researchers or the research resulting from their reflective understanding. Dr. Jhimli Sengupta discussed the concept of action research and its purposes, principles, practice and evaluation in her paper.

Due to the COVID-19 pandemic online (or distance) learning has become an increasingly important part of educational programs. Availability of a range of free and open source software tools for basic and higher-level mathematics can play a vital role in teaching and learning particularly in distance learning environment. Ranjan Das introduced some of the easily available important free open source software which can be used during the online teaching-learning programs specially during the pandemic.

Concept mapping is a best way to build upon former knowledge by connecting new information. In the article “Concept Mapping in Science Education” author gives a different aspect on student intellect that complements selected-reaction and performance-based documents. A concept map is a method to understand the relationship between different theories and concepts.

Knowing the history and philosophy of any particular subject in science is an essential component of science education and recently it has garnered wider interest. Dr. Amrit Krishna Mitra portrays the importance of "Philosophy of Chemistry" and the "History of Chemistry" towards chemistry education.

Skills plays a major role in the overall personality development of an individual. Skill based learning or skill development refers to either acquiring of skills or enhancing of existing skills to the level which is parallel with the ongoing work front. The ninth paper by Divya et al. shows that introducing and implementation of models like skill-based learning, problem-based learning and research-based learning increases the quality of learning. There are more chances of innovation along with the better credibility.

Dr. Subhas Chanda Bhat opines that innovation in science education is an essential part of education system of whole world that make natural science as student friendly subject to learn. So, innovation in science and innovation in science education must walk hand in hand for better learning and understanding.

Due to the rise in the rate of discovery, as a direct consequence, legal freedom decreases. From the paper "Science and Legal Knowledge with Special Reference to IPR" we come to know that the Legal knowledge of IP provides a solution to various conflicts and a policy framework that allows the transformation of intangible resources into sustainable development assets by promoting and protecting innovation and creativity, which will eventually help innovators cultivate Science fruitfully.

Systems thinking provide information of chemical reactions for a good understanding of how the knowledge of chemistry links socio-economic, technological and environmental aspects of the world. In this manner a article outlines the recent development in including systems thinking in chemistry education.

In this era of globalization, to meet the challenges faced by human society related to issues and problems of environment and availabilities of resources, green chemistry is becoming the strength which is leading towards sustainable development. The various principle of Green Chemistry and its implication towards sustainable development have been discussed.

'Virtual lab' is to stimulate computer software that can provide a virtual three-dimension image of the laboratory. Dr. Amit Saha Roy, in his short and informative manuscript, explain the potentiality of 'virtual lab' tools to support the online teaching.

With the help of modern Technologies, the science education now a days frees itself from conventional mode of teaching and making the learning process more attractive and interactive. Madhushree Das Sarma discuses about the Science Education.

Bakra performed a case study on three villages from Sundarbans and observe the agricultural practices of the rural people, livelihood pattern related to estuarine river and mangrove forest.

With the degree of advancement of Science, we are facing burning problems such as global warming, greenhouse effect, energy resources, food production, genetic modification, and Societal Challenges. Subhashis Bala and Hari Shankar Biswas discuss about the Issues and Challenges in Innovation in Science Education.

The editors would like to thank all the authors for their contribution in such varied topics that will help to introduce educational approaches that are needed to emphasize critical thinking and support knowledge integration. Research on Science Education encompasses quantitative, qualitative and mixed methods to name a few. This book tries to explore valid and trustworthy work that takes on a variety of forms and embraces new capabilities at hand, particularly around new technologies. Innovative practices and their relationship with science education is at the forefront of this book.

Hari Shankar Biswas
Sandeep Poddar
Amiya Bhaumik

The Editors of Advances in Science Education

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The editors are greatly indebted to all contributors of papers for the book ***Advances in Science Education*** who have devoted their valuable time and effort on studies relevant to this area of national and global economic importance for every sector.

There is no source of sponsorship or finance for this edited volume. The editors are thankful to Dr. Indranil Kar, Principal and Dr. Suchandra Chatterjee, Head of IQAC, of Surendranath College (DBT Star Strengthening Scheme), Kolkata, India, the management of Lincoln Research and Publications Limited, Australia for publishing this edited book and also to the management of Lincoln University College, Malaysia.

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Editors of Advances in Science Education
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Chapter 1

Importance of Science Education to Achieve Sustainable Society

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Dr. Debarati Dey obtained her M. Sc. In Chemistry from Calcutta University, India in the year 2003 and Ph. D from Jadavpur University in the year 2009. After serving at Heritage Institute of Technology for six and half years, she joined Vidyasagar College, Calcutta a premier institute of the country in the year 2015 as an Assistant Professor. Dr. Dey has written several articles in National and International journals and books.

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Importance of Science Education to Achieve Sustainable Society

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ABSTRACT

Education of science and technology is at the heart of the sustainable development. When the knowledge acquired from education is not isolated within the institutions, rather spreads in regular life and also broadly in society, the circle of learning gets completed. The basic knowledge of science and technology must be correlated with different environmental phenomena so that students feel interest and think about the associated corollaries. This eventually led them to know the burning problems of modern world and seek the possible outcomes. If the young generation be alerted from the very beginning, they will be cautious about the improper use of the environmental resources and be careful about their neighbourhood. This conscious mind will slowly move towards the sustainable world.

Keywords: *Sustainable Development; Education; Science and Technology; Environment*

INTRODUCTION

Sustainable development (SD) is the core of any development. The idea of sustainability depicts various criteria, goals, and aspects. Sometimes this becomes confusing to detect the actual motto of SD. So, the perception of SD may vary person to person in the society. Politicians often highlights only a segmented part of problem and avoid the true sense of SD. Projects are often designed to mitigate poverty, unemployment at the cost of eradicating forests or natural habitats. On the contrary, SD of a place must not be ignored or overlooked. Thus, a central paradigm of overall goodness must always be considered as key of any developments. Science and technology (S&T) are the nutshell of this double-edged sword of urbanisation versus loss of natural environment(Clark & Dickson,2003). Therefore, S&T, the role of government and education of the civil society are the three main pillars of SD with equal balance (Ahmed *et al.*, 2004).

The modern world is struggling in getting rid of these three main problems: i) waste management ii) energy crisis and iii) unemployment. Waste management can partially be solved by recycling the waste. Because circular use of material is always advisable than one-time use considering cost optimization and preservation, and this is best done by means of S&T. An alternate way in resolving energy crisis is to more use of solar energy, windmill, hydroelectricity etc and this demands more and more development of S&T. The unemployment is a social problem that can be resolved by social reforms in educational systems. Education in S&T and innovation help students in acquiring adequate knowledge to identify actual real-world problems and its probable solutions.

REVIEW OF LITERATURE

History of sustainable development

The concept of SD started long back early in 1970's. The first World Summit was held in Stockholm in 1972, emphasized on preservation of biodiversity with simultaneous industrial growth. The developing and developed countries were not matched their viewpoints and objectives towards this environmental protection. After ten years, Nairobi Summit in 1982 stress given on intensified environmental conservation plan. In 1983, United Nations Commission on Environment and Development was created. Next, 'The clear modern concept' of SD came from the Commission's report in 1987 known as 'Brundtland' report. In this report, SD was defined as 'development that meets the need of present without compromising the ability of future generations to meet their own needs'. In 1992 the 'Earth Summit' at Rio, brought world's government and non-governmental organisation within Agenda 21. The agenda describes a comprehensive blueprint of actions toward environmental protection and SD. In this summit it was voiced, 'Human beings are at the centre of concerns of SD. They are entitled to a healthy and productive life in harmony with nature.' In 2002 the World Summit on SD (WSSD, 2002) held in Johannesburg. People realised on that summit that the inertia against environmental conservation had not at all removed and Agenda 21 progress around the world was not admirable. Therefore 'WEHAB' was given on priority in this summit i.e. the importance of need of Water, Energy, Health, Agriculture and Biodiversity. Agenda 21 and WSSD 2002 was failed as common people were not aware of environmental issues due to lack of education. The mass education regarding the importance of healthy nature and environment was not incorporated in any summit's agenda. In 2005, the United Nations Decade of Education for SD was founded to initiate environmental education at all levels, from schools to universities, to cultivate the idea of SD into young generations. The goal is to make visualize childhood people and aware the recent challenges faced by human civilization. This in turn will help researches in universities and research institutes will move immensely towards improving every aspect of ecosystem.

Role of education in sustainable development: An interdisciplinary holistic study

The concept of SD is not one dimensional, rather multidimensional and composed of complex relationship between environment, society, economy, and essence of almost all fields of basic sciences (Figure 1). One of the main aspects of SD is the correlation of

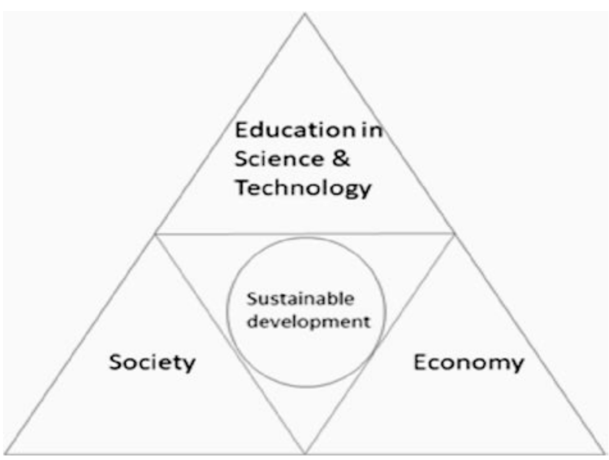

Figure 1: Relationship of SD with Education, Society and Economy

interdisciplinary fields (biotechnology, molecular biology, biochemistry, food and nutrition etc) with traditional science, health and medicine. Knowledge on nature and environment demands deep study in chemistry, physics, mathematics and various streams of biological sciences. The natural resources of air, water and land all are being polluted by manmade activities and because of human civilisation (Van Eijck & Roth, 2007). Our new generation must be aware of regarding the possible ill effects and self-motivated for the remedies to make the earth sustainable for human civilisation (Nevin, 2008).

Air pollution: The continuous emission of toxic and greenhouse gases in the earth's atmosphere increases the average temperature of earth's surface and also causes deleterious health problems. In addition, the suspended particulate matters in the atmosphere decreases the visibility of air, generates smog by combining with other nitrogenous and sulphurous gases that causes severe bronchial diseases. Acid rain is also generated due to air pollution that causes severe damage to plants, agriculture and historical monuments. It also causes leaching of heavy metals like Cd, Hg, Cr etc within the earth's crust that may enter into the food chain via plants and animals or through drinking water supplies. Depletion of stratospheric ozone layer is also a dangerous effect of air pollution that occurs due to emission of chlorofluorocarbon compounds, which have been used as refrigerant in air conditioner, fire extinguisher, solvent etc. The excessive stability of those compounds intensifies the problem. Formation of ozone hole allows the harmful UV rays from sun to come in the troposphere that causes skin cancer, reduced photosynthesis, lung and eye irritation etc.

Water pollution: Natural water resources are getting continuously polluted with agricultural, industrial and household wastes. The pesticides, salts, nutrients, pathogens, heavy metal are the main contaminants in water. All these decrease the amount of dissolved oxygen in water that induces bad smell and is an indicator of polluted water. If water us polluted with some pathogen then the water may cause various diseases like cholera, typhoid, dysentery and water related diseases like malaria, dengue etc.

Land pollution: This occurs due to wastes generated from industry, household garbage etc. Some solid wastes like radioactive wastes, biomedical wastes must be treated with utmost care to avoid public exposure.

The generation and control of the above major pollution needs intensive knowledge in various technical fields. Despite of knowledge, a moment's negligence may cause severe accidents that may cause not only life risk but also far reaching consequences. Bhopal gas tragedy in 1984 in India, Chernobyl disaster in Ukraine in 1986, Minamata disease in Japan in 1956 are some severe accidents occurred due to human negligence and ignorance. Several thousands of innocent people died in those accidents and millions suffered dangerously even generation after generation. Proper rehabilitation of the sufferer is often neglected by government. Such unfortunate incidents must be handled with great care and humanity to save lives and improve the damage with highest priority. The Earth summit at Rio in 1992 highlighted the declaration that 'polluter -pays-principle' and some precautionary measurement was also taken to conserve nature and protect its habitat.

Use of improved science and technology to attain sustainable development

Science and technology (S&T) play pivotal role for tracking the major problems against SD (Economic and Social Council, 2019). It offers various opportunities to reach the desirable goals of SD. E.g., security of food can be achieved in four stages: i) food availability, ii) access, iii) use and iv) stability. The chain of information can successfully be circulated using modern technical equipments. This practice will reduce the wastage of food in certain region and scarcity in some other places. In addition to that firming is increasingly demanding automated cultivation with robots and artificial intelligence. Genetic sequencing and generation of new hybrid plants increases the productivity and enhances crop quality. Satellite information about the weather helps farmers to take quick decisions for betterment of their crops. Various agricultural innovations strengthen the farmer-scientist bonding by proper knowledge transfer using different technical media.

In the energy field the role of S&T has increased dramatically to reduce the use of fossil fuel and generation of renewable energy sources. This includes the reduced cost of solar photovoltaic modules, wind turbines etc in recent years so that they can be used in large extent by common people. The use of clean energy sources is possible via use of smart grid, artificial intelligence, machine learning algorithm etc i.e., direct involvement of S&T to reach sustainably developed society.

Another use of S&T in confronting diseases is unquestionable. Recent advances in biotechnology makes gene editing possible to develop new medicines and personalised treatment is feasible within accessible financial range. Recent outbreak of COVID-19 virus can also be identified and controlled by unrevealing the genetic information of the virus and exchange of knowledge throughout the world. Emerging technologies for healthcare, communication of required awareness, research and development, proactive nature of government, direct participation of entrepreneurs including private sector to sponsor research and development inclusively help to combat against such pandemic situation.

Unlike pros, the modern technical advancement is also having some cons side (Economic and Social Council,2019). Rapid technological growth directs automation i.e., avoiding the manual labour for repetitive jobs and use of artificial intelligence. There may be a negative impact in the employment due to this which apparently seems to be against SD. Despite this, automation is an indispensable part of SD in modern world as it increases productivity and also improves the quality. This saves human energy and time for new non-routine and innovative projects. Beside automation, rapid technological change makes the divergence between developing and underdeveloped communities more wide. The percentage of internet user is really very less in underdeveloped countries compared to a developing country which is obviously against SD.

CONCLUSION

The theoretical learning of S&T gives us the basic idea about the environment and ecology. The real-life environmental problems are more critical to handle as it is intimately associated with social and economic aspects. After learning the preliminary S&T students must be exposed to some real local problems and suggest their opinion regarding that. Beside these students can involve themselves in various drama and cultural events that attract and eventually enlighten the common people about the daily life precautions that can be taken to keep not only the environment safe and soothing but also sustainable. Using liquefied petroleum gas instead of coal, using toilets (public/private) for sanitation, separate garbage bags for biodegradable and non-biodegradable wastes, conservation of rainwater for future use, plantation and regular monitoring of them are some general awareness that students can develop among the society. The specific problems of industrial area must be sorted out with discussion among industrialists, labours, politicians and common people and implementation of proper rules. Thus, by involvement of all, the earth will become sustainable for future generations.

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Chapter 2

Experiential Learning : Analysis of Impact on Students About Literacy of Insect Conservation

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Experiential Learning : Analysis of Impact on Students About Literacy of Insect Conservation

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ABSTRACT

In modern technology-based society little or no positive outdoor activities lead students to grow up with an idea about nature and they are not having interest in conserving the ecosystem. To germinate the seeds of conservation and to initiate conservation process and to enhance the knowledge, skills, attitude of students towards insects - STSP (Student-Scientists –Teachers– Parents) partnership is essential. The curriculum of insect conservation is framed and mapped with the core curriculum of the College. The curriculum is designed for Grade one of graduation. Total 25 students participate in the study and they are assessed on the following parameters like the learner's affinity, perception, attitude towards insects, science and nature before and after conservation programme. Study design is mixed method and data is collected through open-ended questions and Likert type statement. Results of the study reveals that students have improved positively on having affinity, perception and attitude towards insects, wildlife and nature. Students have positive mental attitude towards working with teachers and scientists. Experiential learning activities provide and enhance the literacy rate towards the life of insects and initiates for its conservation.

Keywords: *Insects; Wildlife; Biodiversity; Conservation and Education*

INTRODUCTION

Insects are chitinous, haemocoelomic, hexapod, egg laying, invertebrate animals within the phylum arthropod. Insects are bioindicators and they are the most diversified community and they represent a variety of habitat. They are important for their diversity, ecological role, and influence on agriculture, natural resources, and human health. Insects create the biological foundation for all terrestrial ecosystems. They disperse seeds, pollinate plants, cycle nutrients, maintain soil structure and fertility, control populations of other organisms, and provide a major food source for other taxa. Most insect pests in agriculture are non-native that have been introduced into a new ecosystem, usually without their natural biological control agents. Insects compete humans for the products of our labor ever since cultivation of soil began.

The students today are often restricted to stay indoors, and they have less freedom to explore nature. The time spent outside has been replaced with the time spent over by watching TV, video games etc. Every student must be exposed to nature and must be motivated to love nature. The emotional development of the student is influenced by the experiment gained and by the valuable time spent with the family, parents and nature. The germination of environmental awareness is the key component of the home (informal) and educational institute (formal) education to encourage positive attitude. Positive outdoor experiences lead a student to become a citizen who is aware about environment. Students are fascinated by the nature's discovery. Across the globe, students are becoming less likely to have direct contact with nature. A key driver is rapid urbanization and results in major decline of opportunities to experience nature yet, there is a growth in secondary past-time activities like insect watching etc.

Insects offer virtually endless opportunities to teach and learn by their presence in every habitat and ecosystem. Students may experience all these on regular basis. Current estimates suggest, there are approximately 5.5 million insect species buzzing, creeping and crawling across planet earth., with only one fifth of these named (Stork, 2018). The number of threatened and extinct insect species is woefully underestimated because of so many species being rare or undescribed. However up to 40 percent of insect species worldwide are likely to become extinct in the coming years (Powney *et al.*, 2019). To generated awareness among undegraduate students, a lesson plan about insects is developed.

The outdoor activity provides an opportunity for environmental education proficiency practices in Science. Education with flexibility provides push for creativity and innovation. The traditional method of teaching in the present century becomes obscure. Experiential learning, evidence-based learning and outcome-based learning are the need of the day. The visual, auditory and kinesthetic learner's composite the classroom. The classroom teaching-learning include multi-sensory stimuli resources in positive response from students. The outcome based learning and experiential learning is the method of teaching-learning in the 21st century. It stimulates collaboration, interdisciplinary thinking and strong communication.

Experiential learning: - It is the process of learning through experience. Experiential learning theory is initiated by a psychologist David Klobe and he emphasizes that the experience influence learning process (Kolb, 1984). Experiential learning is a process where knowledge is generated through transformation of experience. Knowledge results from the combination of grasping and transforming experience. There are two different ways of grasping experience:

- Concrete experience
- Abstract conceptualization

Concrete experience provides information that serve on the basis of reflection. Reflection assimilates information gathered through the concrete experience (Healey & Jenkins, 2000).

Need of wildlife education: - Wildlife and habitat conservation has become increasingly important in the 21st century. Insects are the most widespread form of wildlife encountered by people and are exceptional models of living systems useful in learning about several fields of science. Most species are common and abundant and are not threatened by casual collection activities. The wildlife carrying capacity in many protected areas will significantly reduce due to global warming, pollution, invasive species, and illegal hunting. There have been studies which show that proper education and outreach programmes contribute to sustainable behaviour, promote public support for conservation, reduce vandalism and poaching practices in protected areas, and raise compliance with environmental regulations. They also increase recreation-carrying capacities and have an impact on policies and decisions that influence the environment and natural resources (Figure: 1) (Meadows, 2011). Wildlife education is a

Figure 1: Wildlife Education

teaching-learning process introduced to gather information about specific wildlife resources, habitats, ecological relationships, conservation and management strategies. The curriculum has a potential to germinate the seeds of awareness about nature. Wildlife Science can easily map to the curriculum in Science and Social Science. Topic such as conservation of the endangered species to enrich science and biology curriculum through activities such as class-room instructions, field trip, class labs and participate in Endangered Species Day, art competitions etc. Amalgamation of wildlife in curriculum has the potential to positively influence the student's attitude. Today's learners will be tomorrow's decision makers in environmental policy and law. Students must be encouraged to be aware about their environment and nature. Students are losing touch with nature, missing outdoor experience and wildlife education is a link between nature and the student.

Curriculum design: - The curriculum is developed on insect conservation for Graduation first year.

Objective: - The following objectives are framed:

- To amalgamate wildlife techniques as center point of insect studies.
- Evaluate curriculum through pre-test and post-test to study the impact of

student's affinity, perception and attitude towards insects, wildlife, Science and nature.

Hypothesis: - The designed curriculum would improve and have positive impact on student's affinity, perception and attitude towards insects, wildlife, Science and nature.

METHODS

Five experiential learning activities are developed to cover the aspects of the insect conservation. Curriculum is mapped with Graduation first year. The lessons are aligned with Science curriculum. The lesson includes introduction, backgrounds and procedures, assembling, and clearly well-defined learning outcomes. The lesson plan covers insect identification, survey methods, collection of limited number of common insects by sweeping, citizen participation. All lesson hand outs are prepared and distributed.

Implementation of curriculum: - One Science teachers of Sreegopal Banerjee college (located in Hooghly, Mogra, West Bengal, India) teaching Science in Graduation grade one and 25 students from grade one participates in the study.

Evaluation of curriculum: - Both qualitative (open ended question) and quantitative (multiple choice questions) are used to collect the data. Per-test is conducted before preparing the lesson plan. Post-test is conducted after the completion of the lesson. The two tailed *t*-tests are used to analyze answers. The open-ended questions are used to collect information to know about the activities that are favourable and why.

RESULTS

The curriculum is designed and implemented for Graduation Grade one with 25 students and 25 students in Grade three. All the students are from the same college. Grade three students have improved positive attitude towards conservation of insects, able to recognize, identify insects visiting home and backyard of the college. After completion of the curriculum, post survey is conducted. Students enjoy these activities (Table:1). Most of the students enjoy the activities for identification of insects. Students have improved their knowledge and skills on insect and wildlife conservation awareness (n=25, t=2.43, p<0.05).

Table 1: Students Response to the Curriculum Design

SN.	Theme	Response	Explanation Guide
1	No Activity	4	We do not work too much
2	Experiential Activity	20	Experiential learning
3	Joyfulness	18	Watching for fun
4	Visuals	15	Watching insects with magnifying glass to watch closely
5	Outdoor	7	Watching insects

After completion of the curriculum, post survey is conducted (Figure. 2). Students enjoy these activities (n=25) for insect identification, survey, collection of limited number of common insects by sweeping, interactions with citizen for conservation awareness.

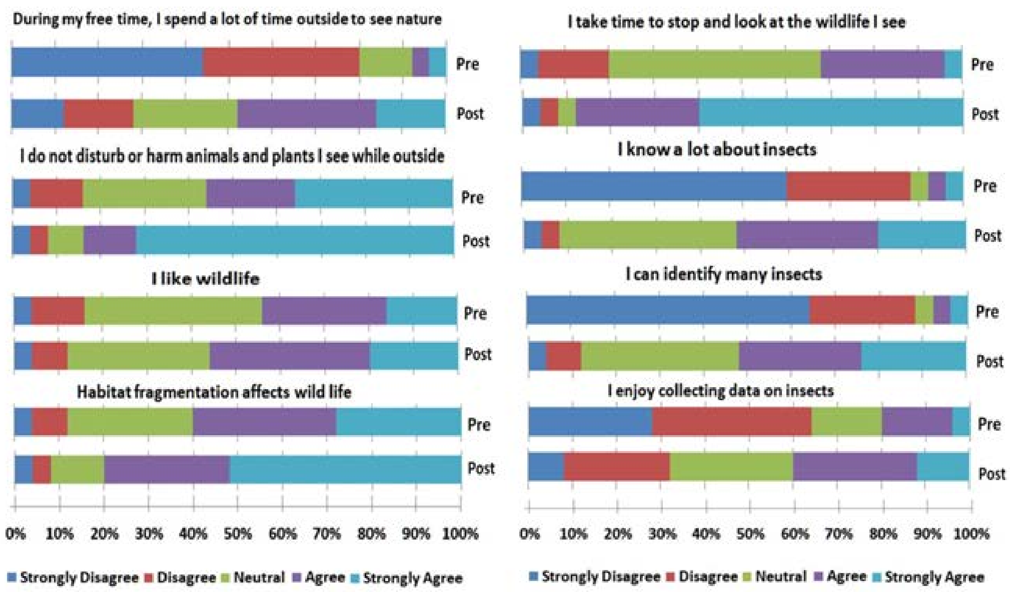

Figure 2: Post Survey Report

DISCUSSION

The study hypothesis has a positive impact on the curriculum on student's affinity, perception and attitude. Students show positive mental attitude towards insects. Students acquire knowledge of habit fragmentation and its impact on insects and wildlife. Ability to identify insects has increased remarkably and able to identify insects at home and at the backyard of the college.

The curriculum design has significantly improved the students' affinity towards insects and wildlife. The time spent with nature, animals have positive impact on the health such as social-ability, self-discipline, concentration, motor skills, ability and curiosity. The time spent at outdoor activities with concentration is fun and has developed positive attitude for conservation. Students use backyard of the College garden for the outdoor activities.

The present curriculum is very effective to enhance the student's efforts to identify insects, conservation efforts etc., at their own level. The quiz on insect biodiversity is conducted to enhance the student's knowledge on insects. The special curriculum has positive impact on enhancing student's interest in the subject, active participation in learning and to enhance academic achievement in the subjects. The students Science processing skills have also significantly increased. The ability of the student to use Science processing skills is the evidence of learning. The outdoor activity in Science if planned effectively and efficiently then it will enhance the learning positively. Outdoor activities enhance conservation related behaviour among learner. The present study shows that if initiation is taken in college properly it enhances the student's positive behaviour towards insects, wildlife and Science.

CONCLUSION

- Educational institutes must equip teachers with tools for effective environmental education among teachers, who transforms the ideologies to next generation for ensuring the sustainable growth in near future.
- Educational institutes must initiate programmes to engage students in scientific process through investigation and monitoring of insects and action to improve biodiversity.
- Educational institutes may raise awareness among students about the importance of insects, habitat and insist on maintaining a healthy environment.
- Encourage students to watch insects and participate actively in conversation.
- Eco clubs may play a pivotal role in spreading awareness of environment education for the sustainable development.
- Educational institutes must celebrate Environmental related days to enhance awareness among students.

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Chapter 3

Interdisciplinary Education Trends in School and Higher Education: A Review

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Interdisciplinary Education Trends in School and Higher Education: A Review

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ABSTRACT

Nowadays, interdisciplinary education is achieving a myriad dimension of human skill opportunity to enhance future decision making capability and design consciousness through multiple academic disciplines. The knowledge economy needs skilled personnel and potential leaders to address various challenges and requirements in companies, governments and societies worldwide. New challenges that we face now and others in near future will definitely require innovative approaches and solutions to solve them. So, existing higher education programmes require an amalgamated approach comprising the essence of different emerging disciplines to train current graduates to address such challenges. This article highlights how interdisciplinary approaches help us to prepare graduates starting from their schooldays for upcoming leadership positions by addressing the multifaceted challenges today.

Keywords: *Interdisciplinary; Education System; School; Curriculum*

INTRODUCTION

Earlier varsity education was intended towards a notioned approach that mostly covers application of a particular discipline in a selective way. But it has shifted its focus over the last two decades as fusion approach acquires utmost importance in addressing complex issues nowadays (Evers *et al.*, 2015 and Nature, 2015). This ideology yields several interdisciplinary concepts which potentially amalgamates different research area in a human friendly manner. Thus societal, environmental, economic and philosophical issues and challenges became easier to be addressed with a synergistic viewpoint. Diverse backgrounds and expertise unveils the advantage of interdisciplinary approach in solving problems, innovation, raising next generation skilled leaders and alleviating research and further development.

Interdisciplinary practices can be of many types, viz., critical interdisciplinarity (Klein, 2005 and Klein, 2010), distal interdisciplinarity (Chavarro *et al.*, 2014), eclectic interdisciplinarity, instrumental interdisciplinarity (Repko, 2011), interdisciplinary capacity building (Lyall *et al.*, 2012), interdisciplinary management, interdisciplinary team work (Nancarrow *et al.*, 2013), multidisciplinary (Moran, 2010), participatory interdisciplinarity (O'Brien *et al.*, 2013) and transdisciplinary.

Interdisciplinary exchange concept came instantaneously in experimental craft labs while craftsmen with different expertise implemented diverse thoughts in the seventeenth century (Sennett, 2013). In recent years, merged creation and idea generation for critical problems has drawn peer attention in innovative development. So, interdisciplinary and transdisciplinary concepts are now successfully coalescing the gap between education, industry and productive research (Ehlen, 2015). The traditional organizational cultures, education policies, management bureaucracies and structures of the institutions sometimes discourage interdisciplinary research as well as funding opportunities often follows such norms and confines its distribution within disciplinary departments and schools. This barrier can be overcome by involving faculty members from different field of study to promote interdisciplinary research following Nancarrow *et al.*, 2013, work on key characteristics essential in this regard.

REVIEW OF LITERATURE

Necessity for interdisciplinary education

Disciplinary learning mostly focuses on predetermined outcome depending on the status of a field of study and related conventional market demand. In contrast, interdisciplinary way of thought can well accommodate the changing nature of futuristic demand that no longer sticks onto specific skillset. Modern engineering education is expected to reflect the parameters of rapidly changing professional world to solve complex unknown problems with its interdisciplinary nature (Mazur, 2013 and 2015). In this approach, the client meets a professional (designer/engineer) and asks for desired result (outcome). The professional then decides and establishes which methods are to be followed and whom (persons from different disciplines) should be appropriate to reach the goals (outcome). This entire flow should have to be incorporated in the teaching, learning and further assessment of students. This can be achieved by problem-based learning formats, case studies, field work, discovery or inquiry learning. If we consider engineering students in this way, they will definitely learn to unveil divergent and ambiguous answers. Thus, different areas could potentially help to find us joint solutions or products through sustainability, entrepreneurship, big data etc. (Akkerman and Bakker, 2011; Lam *et al.*, 2014; Almasi, 2016).

Interdisciplinary research approach

Here one can implement his/her expertise in an introspective manner to solve unchartered problem areas with an integrated approach coalescing different disciplines (Lam *et al.*, 2014; Broto, Gislason & Ehlers (2009); Menken & Keestra, 2016). Statistics of multidiscipline authored articles portrayed in Thomson Reuters Web of Science database (Now Clarivate Analytics) clearly supports that interdisciplinary projects bring together scholars of diverse arena resulting in higher order of research (Voosen, 2013). Funding agencies have felt the thriving prospect of such innovative amalgamation and are encouraging those proposals (Aslan *et al.*, 2014; Bloch & Sørensen, 2014; Hunt & Thornsbury, 2014).

Interdisciplinary teaching and degree referring approach

In recent years, choice-based credit system became attractive to undergraduate students of different varsities. Faculties from various departments thus share their valued approach to uncover multiple dimensions. Students can better understand the diverse application of their core subjects in applied domains. For example, AICTE has introduced biology for engineers course in every engineering discipline to introduce undergraduate students with potential application in biomimetics, medical imaging, point-of-care diagnostics and biomedical engineering. On the other hand, Massive open online courses (MOOCs) has generated a new mobility in interdisciplinary teaching as students from multiple discipline can enrol themselves independently to acquire new skillset through online mode (Santos *et al.*, 2014). Eminent institutions like IIT's are now outsourcing knowledge with the help of experts in their respective fields (NPTEL and SWAYAM platforms). These platforms encompasses interdisciplinary fields like organizational behaviour, management, public health, environmental studies, biomedical sciences, law, engineering, rural development, agro-based disciplines and energy studies(https://swayam.gov.in; Kurup & Arora, 2010; Gonzales *et al.*, 2012; Vale *et al.*, 2012). Same essence is now being followed in several degree programmes at college and varsity level to fulfil present need of employers.

Interdisciplinary teaching approach in school education

Generally the education system of school level is based on conceptualization of different theories of a particular discipline, remembering them and carves them on answer sheet during examination. But concepts without connection to real-world applications are easily forgotten by the students and become irrelevant after some time (Ciesla, 2009). From a report done by the Conference Board, Corporate Voices for Working Families over 400 employers across the United States, during 2006 showed that about 69.6% higher school students are showing lacking in critical thinking, 54.2% in creativity, 34.6% in collaboration, 80.9% in communication (writing)(http://www.p21.org/storage/ documents/ FINAL_REPORT-P DF09-20-06.PDF). During last few decades a huge gap has been observed between academic curriculum and the real world application field. Students who are highly educated from the most reputed institutions of our country failed to solve the practical troubles in the working place. To meet the challenges of the 21st century education system mainly in preparing students with application skills, creativity, thinking ability, communication skills and team work or collaborative work ability several pedagogical strategies have been introduced and examined in school education system (Styron, 2013). Among them interdisciplinary approach, multidisciplinary approach and transdisciplinary approach are mostly discussed (Drake & Burns, 2004). All the approaches help in development of integrated learning which in turn helps in holistic development of student's personality by according of school/college learning with real life.

Pedagogies in interdisciplinary teaching approach

Interdisciplinary teaching means the exercise and integration of knowledge and teaching/learning method from more than one academic discipline to examine a theme, issue, question or topic (Pancheva & Antov, 2015). In this approach while studying a topic students has to understand knowledge and modes of thinking from two or more variety of relevant disciplines or subject groups, combine the collective information to create a new understanding and integrate these ideas into a more complete knowledge that can be used in explaining a phenomenon, solving a problem, creating a product, or raising a new question or idea (Helmane & Briška, 2017). Interdisciplinary teaching is different from other teaching approaches in that it requires the integration and amalgamation of different perspectives rather than a single viewpoint or discussion of different viewpoints. To develop interdisciplinary skills and concepts of students, educators design the curriculum by choosing more than one subject based on common learning across disciplines and then integrate on the basis of skills and concepts common for two disciplines in such a way that processes and concepts of one discipline help to develop understanding about the other one (Figure 1). The approach is very much student oriented. Deeper levels of conceptual coherence, varied set of reasoning and meta cognitive strategies are observed as an outcome. Increased cooperation between teachers and students along with student-student and teacher-teacher interaction are also an outcome of interdisciplinary strategy (Styron,2013). Two teaching techniques, or strategies, are employed for implementation of interdisciplinary education is Team-Based and Inquiry-Based Learning. Both the techniques rely on group learning and encourage critical thinking, creativity, collaboration and communication skills.

One study in Turkey Primary schools during 2012 showed that when an interdisciplinary approach has been followed in primary school education by collaborating the subjects and activities of a school subject in the curriculum with other subjects, students got better understanding of various subjects, they became more creative, self-confident, better learner and more proficient in each subjects (Deneme & Ada, 2012).

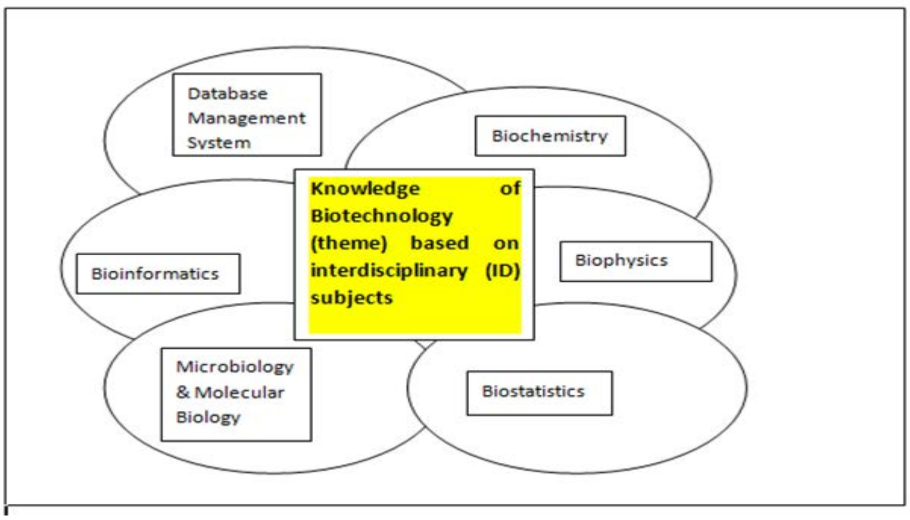

Figure 1: Interdisciplinary approach of teaching/ learning method

Here curriculum of a course taught in High school teaching, Biotechnology, is developed by integrating some relevant disciplines like Biochemistry, Biophysics, Biostatistics, Bioinformatics, DBMS, Microbiology and Molecular Biology and others.

CONCLUSION

For development of students 'competences and life skills, Interdisciplinary teaching/learning approach is very effective than traditional one-discipline-based approach. But there are several challenges for the educators to employ this approach as they had to integrate the linked subjects during preparation of curriculum. For this both the instructors and students need proper training system on different interdisciplinary pedagogical strategies, such as Team-Based Learning, Inquiry-Based Learning, etc.along with some topics related to this approach such as outcome based curriculum development, collection of feedback from students, parents and all the stakeholders, development of effective assessment system etc..

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Chapter 4

Problems of Science Education and Research

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Problems of Science Education and Research

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ABSTRACT

Progress of society can take place with the progress of education in Science and Technology. This is also true when we talk about ongoing COVID-19 pandemic situation. In the mid of this pandemic, when we talk about entertainment, online delivery of grocery, classes in colleges and schools, organization meetings etc. , all of these are possible due to the same. So, one can say that science can make us survive in any adverse situation. But after four decades of independence, the enthusiasm to provide science education has decreased and more involvement is in vocational field or non-basic science field. Basic sciences are the backbone of rest of the allied field. There are many problems in the field of science education and its research. Hence, in this paper author wants to drag the attention towards the problems faced by our country in progress of said field and also suggested the some measures to mitigate the gap between study and research.

Keywords: *Problems; Measures; Adverse, Pandemic; GDP; OERs*

INTRODUCTION

Science education has a prestigious career in the society of India. From the very beginning, Science remains Indian's first choice in stream of education for their children. With the establishment of educational institutes in Indian states, more emphasis was done for the practical aspects of the subject. But since 1990s, education has faced a great downfall in the country like India in the field of science stream. More emphasis has been done in the sphere of modernization and other facilities in different field of educational departments but no investment in practical functioning laboratories (Chandran & Muralidhar and Wolff, Saliba, Diision, Dparment & America,1991). Basic science departments are shown as an outdated field of study and one who chooses are of low standard families & will earn very less. Now, with the advent of online education systems, one can think to minimize the hurdles in the science education in India.

REVIEW OF LITERATURE

Problems

Till 40 years after Independence of our country, education system was managed with proper investment and facility. But after 1990, this field of human capital preparation has faced a great set back. The problems of this deteoriation in Indian Education system are as follows:

- Less investment education system in budget: Very less percentage of Indian

GDP has been invested on education system by our government. A large amount of GDP is invested on subsidies and other departments.

- Lack of teaching staff in colleges and schools: - Some stakeholders in connection with political people wanted to make money from schools and colleges. This resulted in the establishment of private schools and colleges with proper advertisement. But it was not possible without degradation of the government organization and in order to degrade they had to make human capital nonfunctional or of poor quality. This was done by not having recruitment of teaching staffs in government organization and forcing the staffs to work more to complete different task. By doing multiple tasks, teachers could not be able to do their teaching work properly. Recruitments are also done on adhoc or contract under very low price for work in which less capable candidates apply and work.
- Science education without practical: The private education institutes are providing science education just as literature subjects and students are just rote learning and vomiting in the exam paper. This has totally collapsed the scope of the subject.
- More investment on infrastructure and other show out items (Kishore, 2009): The institutes invest more on building construction, making concrete paths, tiles fitting in buildings, beautification, lifts and other items. They only show the institute from outside without investment in educational supporting materials such as laboratory instruments and chemicals, books, journals, library etc. Wi-fi facility is available in institute but access facilities remain non-functional & it is only used by office staffs.
- Research work without grants: Most of the young research does their Ph.D. and other research without any research aid on their own cost. After investing a large amount, they withdraw themselves from the research and brilliant brains either go to foreign countries or change the field of profession.
- Problems to get credits of scholarships: - Many good students do not be able to receive scholarship or grants for their study due to more headache to tackle office staffs of the institute.
- Instruments of research grants centralized to only a couple of faculties: - Government provides grants to purchase modern instruments and equipments by scientific proposals & different grant agency. But the instruments are used by only faculty who has been granted by the agency. No other person can.
- Nonfunctional costly instruments without technicians: - Many departments of science and technology are with a large number of new instruments of crores of rupees but locked in rooms due to no technical staff present in the institutes.
- Replacing science education by e-learning: - Now students are involved to study science with online OER (Open education resource)1 materials. The students learn no doubt, but it is not affordable to many families who earn less (Agarkar, 2016).

DISCUSSION AND CONCLUSION

Measures to uplift science education

- Research centers on different parts of India: - To minimize investment of money in research, six to ten centers should be made which should be centralizes. The research centers or institutes should be approachable from its surrounding towns. All instruments of research need should be available at those centers with levying minimum fees. No research unit can deny providing facility for different tests if so; the institute should be punished with penalty against the pay of the employee making such statement. This will increase young minds to get nurtured. Also, the government expenditure on multiple number of instruments having same function get minimized (Thimmappa, 2015).
- Training faculty in different fields of research: - The science faculties should be provided training facility in different research stations compulsorily. This can be done by sending them to different laboratories of the country to work with the scientist. This will make them to contribute research and connect new generation with the new inventions which make them to compete with the world.
- Easy credit of Scholarship: Scholarship should be easily credited to the bank account of the students so that they could easily use the money to study and research.
- Availability of the research instruments: - Research instruments should be available to the institute by centralized committee formed by the union government and no money should be provided to the researcher to make profits after taking the grants.
- Free online. books and instruments functioning demo (Wolff, Saliba, Diision, Department & America, 1991 and Hassan & Salihu, 2020): - Free online books which are now not in publishing should be available to our students so that they could derive knowledge from them. Also, many instruments which are common, but students are not known should be made online available. Many small toys and machines can be used to teach the principle of science behind its working.
- Stop privatization of education due to online: - Online education is a boon in the world of Covid 19 pandemic. But it has also resulted in involvement of many multinational companies to make apps and sell the content by making videos. This result education to get far from the reach of the poor human resource.

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Chapter 5

Action Research: Purposes, Principles, Practice and Evaluation

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Action Research: Purposes, Principles, Practice and Evaluation

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ABSTRACT

Action research is an interactive and systematic process for assisting concerned researchers improving the actions taken by them. Over the years, many methods for action research have evolved, which focus on the actions taken by action researchers or the research resulting from their reflective understanding. In this paper, we discuss the purposes, principles, practice and evaluation of action research.

Keywords: *Action Research; Methodologies; Principles; Triangulation*

INTRODUCTION

Action research is a method of systematic inquiry undertaken for and by the entities taking the action. The primary reason for pursuing such research is to assist these entities or practitioners (e.g., educators) in improving and refining their actions. Action research can be typically visualized as a cyclical process (with different phases: plan, action, observe and reflect), where researchers start with an interesting real-life problem they want to change. The problem is turned into a 'researchable project', and actions are planned and taken accordingly. Finally, data from intervention are collected and then analyzed depending on how successful the actions have been. The problem is then assessed again, and the next cycle is initiated unless the problem in hand is resolved. Researchers involved in action research often find it to be an extensive experience since it is always relevant to themselves, who are the main consumers of the findings. Moreover, action research aims to help educators enormously to be more constructive at teaching and developing the students – which essentially makes the students grow and brings a real difference in their lives (Sagor, 2021).

Action research can be thought of as an interactive process which brings a balance in actions taken for solving problems or in the research to perceive the underlying bases that helps to predict about both organizational and personal changes in future (Wikipedia, 2021), (Reason & Bradbury, 2001). Methods for action research focus on the actions taken by researchers or the research resulting from the reflective understanding of them. Starting from a personal viewpoint of research (aimed at personal change), action research gradually extends to group-level research (aimed at improving a family/team) and further to scholarly research (aimed at large-scale changes or generalization) (McNiff & Whitehead, 2005). Action research extends social science – from reflective knowledge obtained from variables sampled by other experts – to an active theorization, data collection and inquiry. According to (Torbert, 1981), to ask for validity of social knowledge is equivalent to questioning how to plan (and develop) well-informed actions and to carry out them. Action research is an empirical process since practitioners pursue problem-specific investigation in practice – the goal of this process is to generate and disseminate knowledge in social sciences.

Action research differs from other types of research and day-to-day problem-solving techniques. It focuses on turning people in a project into researchers, such that they apply their learnings while they do it. The project should involve real-world situations and aim to solve real-life problems. On the other hand, the basic difference between action research and day-to-day problem-solving practices is that the former emphasizes on scientific studies. Researchers during action research systematically study the problem and ensure that any intervention is based on strong theoretical considerations. They spend most of the time to refine methodological tools to adapt to the current needs, and to collect, analyze and present data in a cyclical and ongoing fashion (O'Brien, 2001).

In this paper, we discuss the purposes and principles of action research, how it is done in practice, and how the evaluation takes place.

REVIEW OF LITERATURE

Purposes of action research

Action research helps practitioners find ways to provide an enhanced quality of solutions. We mention some of the features as follows (Koshy *et al.*, 2010).

1. Action research involves actions, evaluations, critical reflections and subsequent changes in action – which improves practice.
2. It is participative, collaborative and undertaken by participants who have a common purpose.
3. Action research is specific to the particular situation and context in hand.
4. Action research develops reflection depending on the participants' interpretations.
5. Action research creates knowledge through actions based on specific applications.
6. Action research may involve problem solving, if its solution has the potential to improve the practice.
7. The findings emerge following the actions. However, they are neither conclusive nor absolute.

Principles of action research

Action research is founded on several principles. Some of the key guiding principles are as follows (Winter, 1989).

1. Reflexive critique: It is often seen that an account of a scenario (for example, in the form of transcripts/notes/official documents) claims to be authoritative (i.e.,

true and factual) implicitly. However, in a social setting, truth depends on the teller. The principle of reflective critique makes it sure that people reflect on processes (and their issues) and explicitly state the interpretations, biases, assumptions, and concerns depending upon which the judgments are made. Practical accounts can essentially give rise to theoretical considerations.

2. Dialectical critique: In most cases, reality (specifically social reality) is first validated and then disseminated through languages. A phenomenon is conceptualized in dialogues. Consequently, researchers need dialectical critique in order to perceive the set of relationships between a phenomenon and its contexts (and between various elements of the phenomenon). The key elements, that need more attention, are those which are unstable or contradict one another.
3. Collaborative resource: An action-research project consists of participants who are considered to be co-researchers. Collaborative resource treats each participant's ideas to be equally significant for producing interpretive categories of analysis. It avoids the skewing of credibility due to the prior status of an idea-holder. Participants obtain insights from the contradictions among many viewpoints as well as within a single viewpoint.
4. Risk: In action research, a change may threaten earlier processes – which may create psychic fears among participants. Another notable fear is due to the ego coming out of open discussion of one's ideas, interpretations and judgments. The initiators should reduce others' fears by pointing out that they will also be subject to the same process. They should also ensure that, whatever be the outcome, learning takes place anyway.
5. Plural structure: Action research incorporates multiple views and critiques – which may lead to multiple interpretations and actions. For reporting, the plural structure needs plural texts. This implies that many accounts are kept along with their contradictions as well as different choices for the presented action. So, a report does not act as a conclusion, it rather acts as a means for noting discussions among the collaborators involved.
6. Theory, practice, transformation: It is often seen that theory directs practice which in turn improves theory (continuous transformation). Actions are attributed to assumptions, hypotheses and theories; and obtained results enhance understanding of the problem in hand. Researchers are responsible for justifying the situation theoretically, and for challenging their bases. The following applications are subjected to further analysis.

Action research in practice

Action research can be pursued by a single researcher, or by a small (or large) group of people sharing a common interest. It typically involves the following seven steps in practice (Sagor, 2021).

1. Selection of focus: The process of action research starts with serious reflection aimed to identify one or more topic(s) which are worthy of investing a busy

researcher's time for. In other words, no actions are worth being taken unless it has the potential to make the researcher's work more empowering. Therefore, choosing a focus in the first place is of immense importance.

2. Clarification of theories: In the next step, researchers need to point out the values and theoretical perspectives they have regarding their focus. It is vitally important for researchers to clarify the theories themselves.
3. Identification of research questions: Once researchers identify the research focus and clarify the researcher's values, beliefs and theoretical perspectives about that focus, the third step is to come up with various research questions that are personally meaningful.
4. Data collection: To ensure that instructional decisions are based on the best possible data, researchers require the data to justify validity and reliability of their actions. Moreover, they must be confident that the lessons obtained align with unique characteristics of their focus area. Most researchers use triangulation process to enhance validity and reliability of their findings. Triangulation (Bound & Stack, 2012) uses multiple independent data sources to answer related questions. It is similar to studying an object, which is placed inside a box, by observing it through different sides of the box – that helps researchers compare different perspectives. Researchers require the techniques they choose to be appropriate for unique qualities of their focus area. The key to managing triangulated data collection is to be effective and efficient in collecting data and to identify other relevant data sources that may come up during the process.
5. Data analysis: Many procedures help researchers to identify the patterns in their action research data. Researchers typically examine and analyze the data to answer various questions – which helps them understand the phenomenon under investigation in a better way.
6. Reporting results: Once the research results are obtained, the common venues for sharing them with peers are faculty meetings, conferences and journals. Irrespective of the venues or techniques researchers select for reporting, contributing to the collective knowledgebase often proves to be most rewarding.
7. Taking informed action: With data uncovered during the process, researchers feel greater confidence to carry out the next steps. Moreover, with each cycle of refinement of practice, researchers obtain valid and reliable data on their progress.

Evaluation of action research

We briefly discuss some methods to evaluate action research as follows Tomlin, 2015.

1. Attitude survey: Surveys contain predetermined questions to capture different types of responses.
2. Interview: Interviews provide helpful data collected at several stages in action research.

3. Observation grid: Observation grids enable action researchers to work on various aspects that may be recorded periodically.
4. Checklists: A checklist contains a list of things to do or to observe.
5. Focus groups: In a focus group, a small number of learners/researchers discuss one or more particular issue(s) for a short period.
6. Learning log: Experiences are often recorded and reflected using a learning log, a useful tool for action researchers.
7. Document analysis: It includes systematic collection and analysis of documents related to a specific focus area.

CONCLUSION

Action research is a methodology of research based on actions. It looks for transformative changes using the process of taking actions and doing research simultaneously. In this paper, we have discussed the concept of action research and its purposes, principles, practice and evaluation.

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Chapter 6

Free and Open Source Software as Powerful Tools in Teaching and Learning Science in the 21st Century

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Free and Open Source Software as Powerful Tools in Teaching and Learning Science in the 21st Century

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ABSTRACT

Advancement in technological developments in the 21st century has opened up the new ways in teaching and learning basic level mathematics. With the advent of new Choice Based Credit System in higher education in India, teaching and learning through demonstrations have become an important methodology. Moreover, due to the COVID-19 pandemic online (or distance) learning has become an increasingly important part of educational programs. Availability of a range of free and open source software tools for basic and higher level mathematics can play a vital role in mathematics teaching and learning particularly in distance learning environment. This free software can also be applied to various fields of science. In this paper we have introduced some of the easily available important free open source software which we used during the online teaching-learning programs specially during the pandemic. We have also shown how these software can be applied to other fields of science, through which students were immensely benefited. Open source provides nearly endless opportunities for students, teachers and academicians to innovate and take advantage of rich educational content.

Keywords: *Online Teaching; Pandemic; Free Open Source Software; Applied Mathematics; Sage; Geogebra; Octave*

INTRODUCTION

In the 21st century Electronic learning (e-learning) as a form of distance learning is being promoted as the educational medium of the future. New ways have been developed in teaching and learning basic level as well as higher mathematics and also its applications (Heugl, 2004). Use of computers, user friendly software and Interactive Communication Technologies have introduced the new methods of teaching and learning (Arcavi, 2003). Open source tools practically fueled innovation in teaching and learning through demonstrations in the 21st century. There are many free and open source software tools for different level of teaching mathematics particularly in distance learning environment.

With the advent of new Choice Based Credit System in higher education in India, teaching and learning through demonstrations have become an important way of imparting knowledge. Moreover the COVID-19 pandemic required a paradigm change in education in 2020, as face-to-face interaction between teachers and students was hampered. As work and learn from home has become the new normal situation, students and teachers needed a suitable infrastructure for teaching and learning. Open source software gave that platform and helped teachers, students, and families around the world to a great extent during the pandemic.

Open source software (OSS) is a software that is available in source code under a software license that permits users to study, modify, improve and distribute information to other users. These are available within the public domain and individuals who have expertise in software development and an interest in its free distribution very often develop it collaboratively. This software is not generally under copyright restrictions and software developers can modify source code for their own purposes. There are many significant open source software products that have revolutionized many areas of activity including the use of ICT based teaching (Law, 2009).

We shall describe here briefly some of the major open-source mathematical software which are being extensively used in undergraduate as well as post graduate level mathematics teaching and are also being applied to various branches of Science like Physics, Chemistry, Biology, Economics, Engineering etc. While teaching this software through offline/online mode I observed that students were very much interested in learning these tools and they also applied them in solving problems.

REVIEW OF LITERATURE

1. Sage

The full form of SAGE is Software for Algebraic and Geometry Exploration. Sage was initiated in 2004 by William Stein as a project to develop a free open source CAS (Computer Algebra System) that any teacher, researcher or student could use freely and at the same time in the sense that all the algorithms and methods could be checked and improved by anyone (Eröcal & Stein, 2010). Sage is in constant development. There are many useful packages used in Sage. In its web page http://sagemath.org, one can read that the mission of Sage is “Creating a viable free open source alternative to Magma, Maple, Mathematica and Matlab”(Ajit & Kumaresan, 2008).

Sage is based on Python language which is easy to learn and widely used. Sage can be used through a command line interface, but it is easier to interact with Sage through its graphical interface. We can also use Sage like a web server. This is very useful to access our work from any place or to share our work with, for example, students. Even we can try Sage without installing anything through the website http://www.sagenb.org. Our work is saved in at “Sage worksheet” (Mezei, 2016).

Here we are describing some applications of sage math:

1.1. In Fig 1 we have shown the plotting of the polar curve r=acos 6t for five values of a.

```
In [130]: p1=polar_plot(3*cos(6*t),(t,-2*pi,2*pi),color='aqua')
          p2=polar_plot(4*cos(6*t),(t,-2*pi,2*pi),color='pink')
          p3=polar_plot(5*cos(6*t),(t,-2*pi,2*pi),color='violet')
          p4=polar_plot(6*cos(6*t),(t,-2*pi,2*pi),color='orange')
          p5=polar_plot(7*cos(6*t),(t,-2*pi,2*pi),color='green')
          a1=text("POLAR PLOT",(6,6),color='blue',axes=false)
          p1+p2+p3+p4+p5+a1
Out[130]:
```

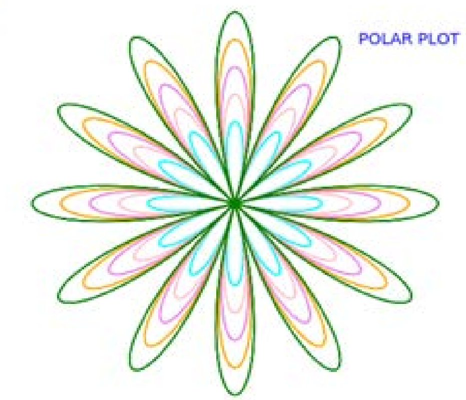

Figure 1: Plotting of a Polar Curve

1.2. In Fig. 2 we have shown the solution of system of equations $x^2 + y^2 = 1,\ x.y = \frac{1}{4}$.

```
In [99]: var('x,y')
         p=solve((x^2+y^2==1,x*y==(1/4)),x,y)
         show(p)
```

$$\left[\left[x = -\frac{1}{2}\sqrt{\sqrt{3}+2}, y = \frac{1}{2}\sqrt{\sqrt{3}+2}\left(\sqrt{3}-2\right)\right], \left[x = \frac{1}{2}\sqrt{\sqrt{3}+2}, y = -\frac{1}{2}\sqrt{\sqrt{3}+2}\left(\sqrt{3}-2\right)\right], \left[x = -\frac{1}{2}\sqrt{-\sqrt{3}+2}, y = -\frac{1}{4}\sqrt{3}\sqrt{2} - \frac{1}{4}\sqrt{2}\right], \left[x = \frac{1}{2}\sqrt{-\sqrt{3}+2}, y = \frac{1}{4}\sqrt{3}\sqrt{2} + \frac{1}{4}\sqrt{2}\right]\right]$$

Figure 2: Solution of System of Equations $x^2+y^2=1$, $x.y=1/4$

1.3. In Fig. 3 we have shown the first four derivatives of $f(t) = ln(1 + t^2)$ and plotted them along with the graph of $f(t)$ in the same figure with different colours, thickness 4.

```
In [18]: var('t')
         f(t)=ln(1+t^2)
         f1=diff(f(t),t)
         f2=diff(f(t),t,2)
         f3=diff(f(t),t,3)
         f4=diff(f(t),t,4)
         z1=plot(f1,-5,5,color='red',thickness=4,legend_label=" first derivative of f")
         z2=plot(f2,-5,5,thickness=4,legend_label=" second derivative of f")
         z3=plot(f3,-5,5,color='green',thickness=4,legend_label=" third derivative of f")
         z4=plot(f4,-5,5,color='orange',thickness=4,legend_label=" fourth derivative of f")
         z=plot(f,-5,5,color='dimgrey',thickness=4,legend_label=" f")
         z1+z2+z3+z4+z
Out[18]:
```

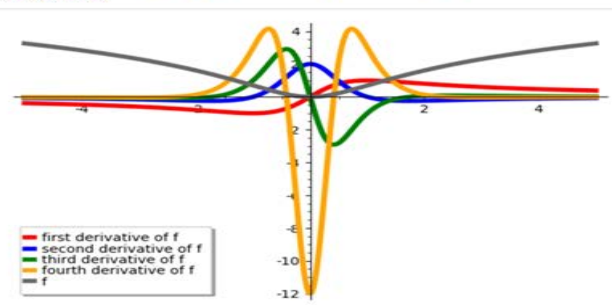

Figure 3: Plotting of $f(t)=ln(1+t^2)$ and its Derivatives

1.4. In Fig. 4 we have plotted the graphs to explain the geometric meaning of Lagrange's Mean Value Theorem (Hoyles & Lagrange, 2010) for the function $f(x)=x^3-4x+1$ in [0.5,2.53].

In [23]:
```
var("x")
g(x)=1-4*x+x^3
t1=line([(0.5,g(0.5)),(2.53,g(2.53))],color='red')
t2=plot(g,0.5,2.53)
m=(g(2.53)-g(0.5))/(2.53-0.5)
h(x)=diff(g)-m
r=h.find_root(0.5,2.53)
t3=plot(g(r)+m*(x-r),0.5,2.53,color='black')
t4=text("LAGRANGE'S MEAN VALUE THEOREM",(1,6),color='green')
t5=text("    IS VERIFIED FOR FUNCTION g IN  [0.5,2.53]",(1,5),color='green')
(t1+t3+t2+t4+t5).show(ymin=-6,ymax=8)
```

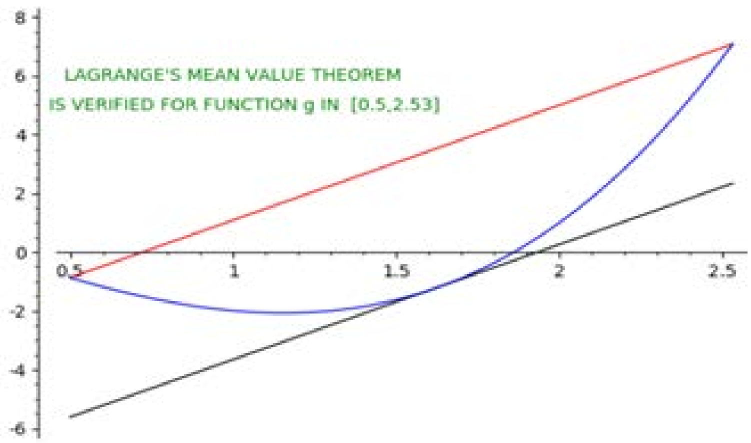

Figure 4: Geometrical Interpretation of Lagrange's Mean Value Theorem

1.5. In Fig. 5 we have shown how to generate a random matrix A of order 3×3 and to find its eigenvalues and corresponding eigenvectors.

In [31]:
```
G=random_matrix(ZZ,3,3)
show(G)
```

$$\begin{pmatrix} -1 & 2 & -2 \\ 0 & 10 & 0 \\ 0 & 1 & 2 \end{pmatrix}$$

In [32]:
```
show(G.eigenvectors_right())
```

$$\left[\left(10, \left[\left(1, \frac{44}{7}, \frac{11}{14}\right)\right], 1\right), \left(2, \left[\left(1, 0, -\frac{3}{2}\right)\right], 1\right), (-1, [(1, 0, 0)], 1)\right]$$

Figure 5: Eigenvalues of a Matrix

2. Geogebra

Geogebra is a free, open source, multiplatform, dynamic mathematics software [Hohenwarter & Preiner (2007)]. In this software integration of dynamic algebra, geometry, calculus and spreadsheet etc. is done into a single interactive package.

Representations of mathematical concepts is based on a strong connection between algebra and geometry. GeoGebra was created by Markus Hohenwarter in 2001-2002 as part of his master's thesis in mathematics education and computer science at the University of Salzburg in Austria (Hohenwarter & Preiner, 2007). The main idea of using GeoGebra into everyday teaching and learning is to provide opportunities for students of different mathematical skills and levels for better understanding concepts and fostering them to doing mathematics in new attractive way.

Geogebra has clear and easily understandable graphical user interface (Hall & Lingefjärd, 2016). It is rich in database of ready-made examples. Its marking objects follow the mathematical syntax and it has the ability to save a project in multiple formats and to work with LaTeX. All objects in GeoGebra are dynamic and are possible to publish the work on the website through javascript. Programs written can be translated into many foreign languages. Geometrical constructions become more clearer since the objects such as points, sections, circles and lines can be moved in any way. In addition all the constructions can be made by point and click technique or introducing them through command line. These features make GeoGebra a great tool for teaching and learning mathematics. Here we discuss some examples solved in GeoGebra.

2.1. In this example we have shown how to construct a circle described on the triangle.

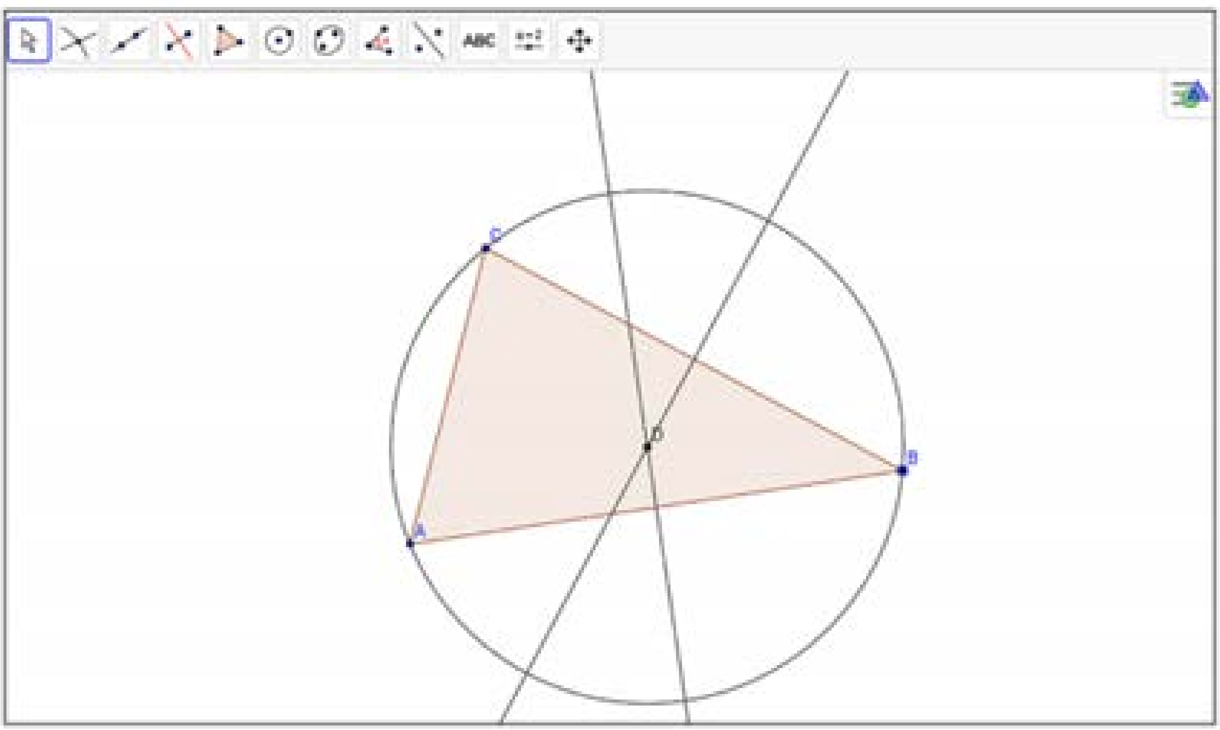

Figure 6: A Circle Described on the Triangle

2.2. In this example we want to show the relationship between the slope of a tangent line of a function and derivative of this function.

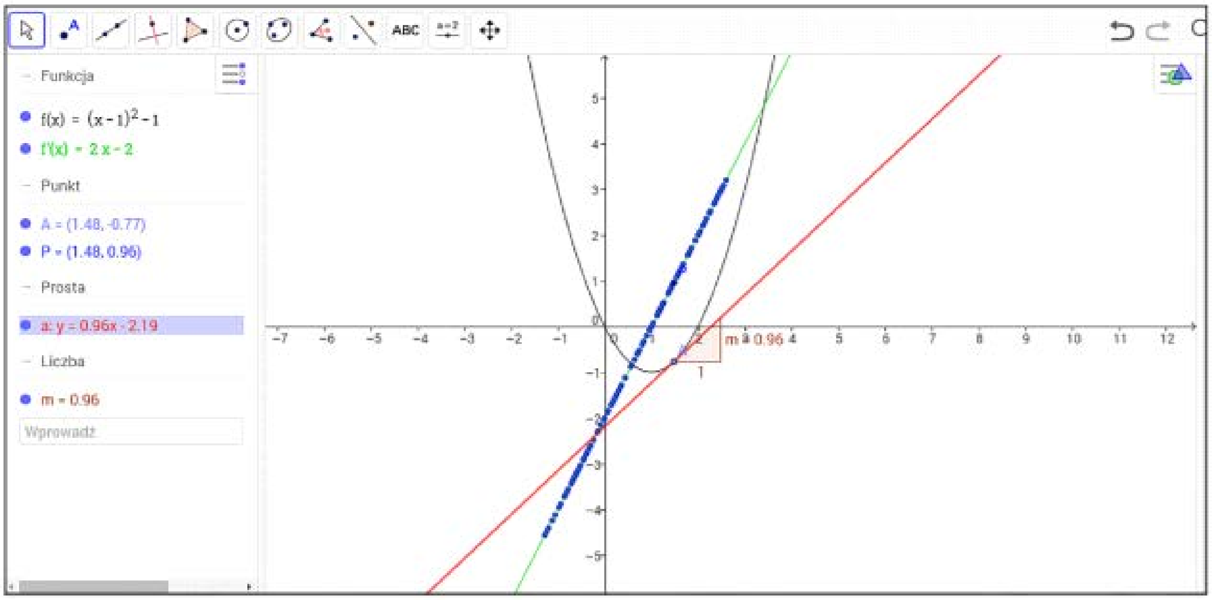

Figure 7: Tangent Lne of a Function and its Derivative

2.3. The use of GeoGebra (as a visual dynamic tool) also supports students' understanding of probability. Here we plot the normal curve for various values of the parameters.

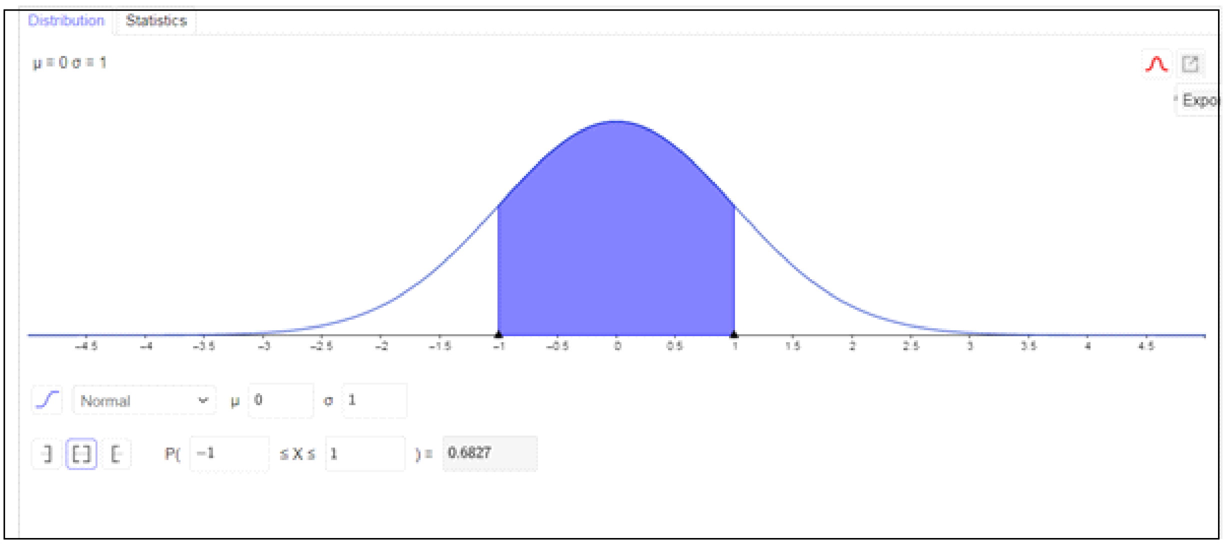

Figure 8: Normal Curve

2.4. In Figure 9 we have constructed a cone and in Fig. 10 we have shown a ruled surface.

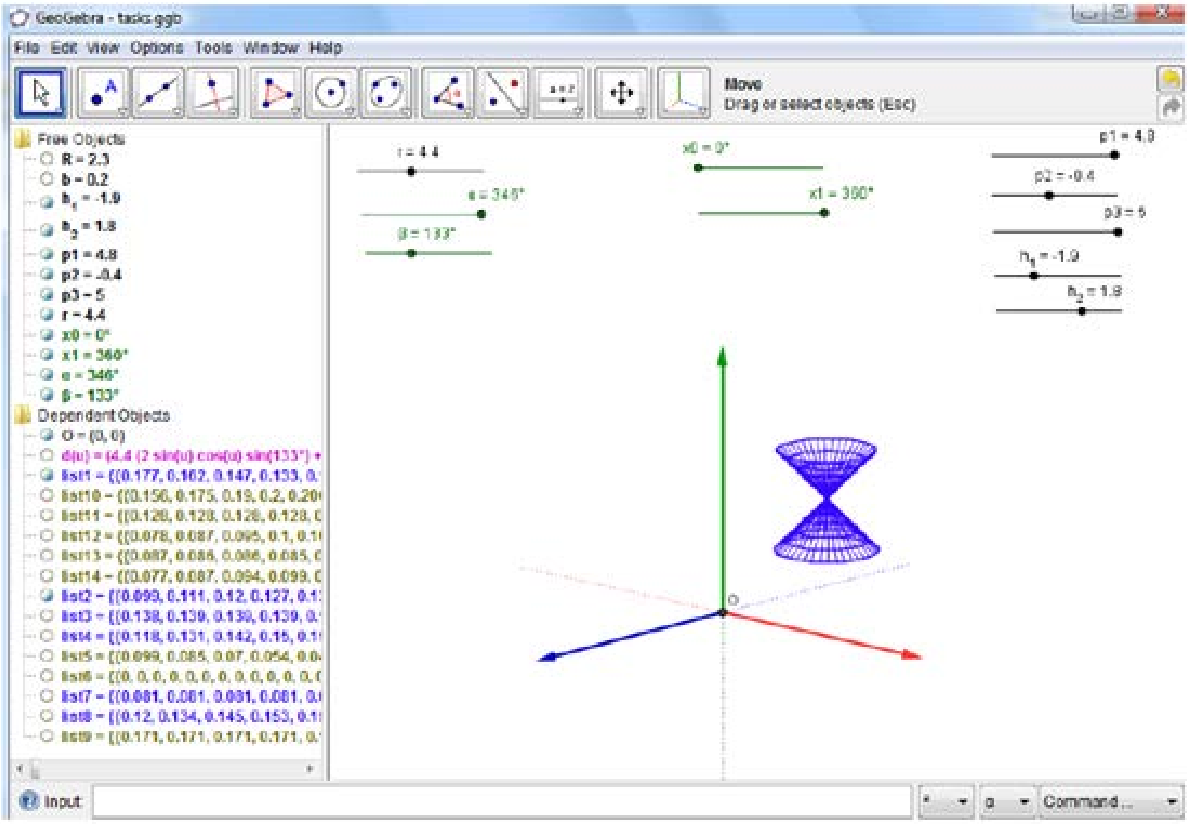

***Figure* 9: Construction of a Cone**

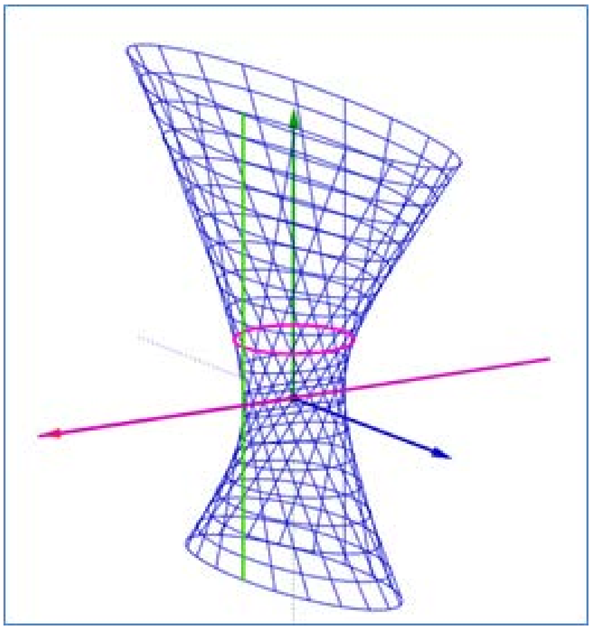

Figure 10: A Ruled Surface Drawn in Geogebra

3. Octave

GNU Octave is a free open source software like MATLAB and it is primarily intended for solving mathematical problems numerically and with graphics. It is designed for matrix computations, solving simultaneous equations, computing eigenvalues etc. In many real-world problems, data can be expressed as matrices and vectors. In addition, Octave can display data in different ways, and it also has its own programming language which allows the system to be extended. Thus Octave makes it easy to solve a wide range of numerical problems, allowing us to spend more time on developing and testing mathematical algorithms (Hansen, 2011).

Octave was originally developed (in about 1988) to be companion software for an undergraduate-level textbook on chemical reactor design written by James B. Rawlings of the University of Wisconsin-Madison and John G. Ekerdt of the University of Texas. It is currently being developed under the leadership of Dr. J.W. Eaton and released under the GNU General Public License (gnu.org). The syntax compatibility of Octave with MATLAB makes its usefulness enhanced in industry and academia. Most MATLAB programs run in Octave, but some of the Octave programs may not run in MATLAB because, Octave allows some syntax that MATLAB does not (Shahin, 2016).

Here we show some important applications of Octave in numerical simulations of Biological models such as Malthus model, Logistic Model, Lotka-Volterra model and SIR epidemic model.

3.1. In Fig. 11 we have solved the elementary biological model due to Malthus and also plotted the graph.

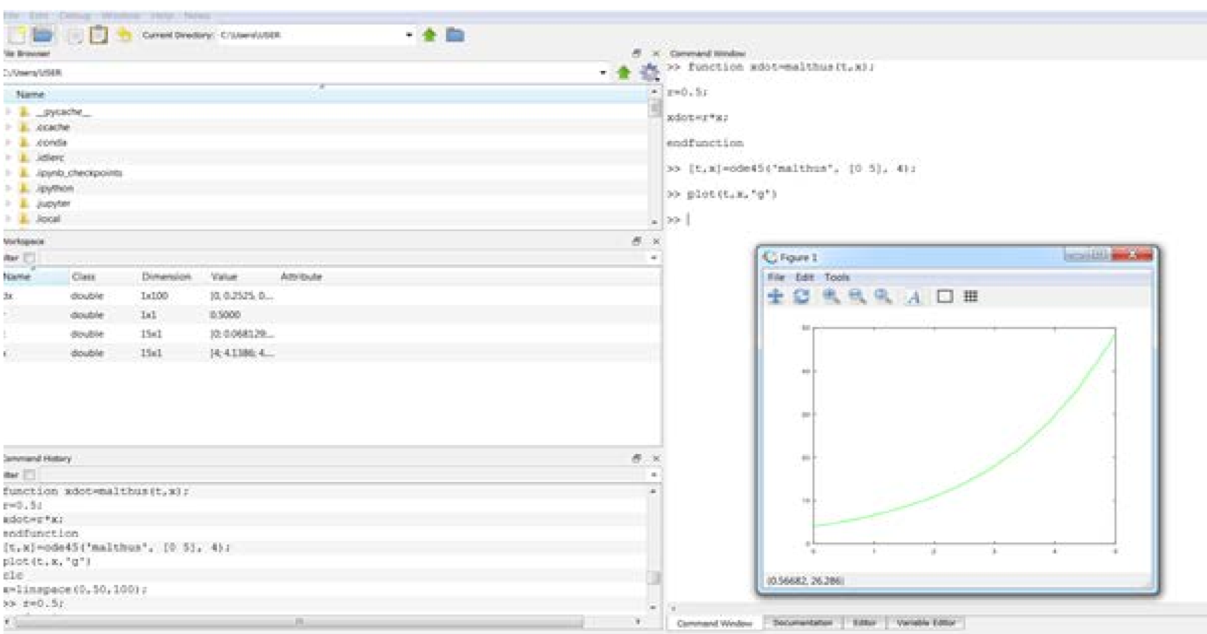

Figure 11: Solution of Malthus Model

3.2. In Fig. 12 we have shown the numerical solution of the famous logistic model of mathematical Biology and also plotted the solution curve.

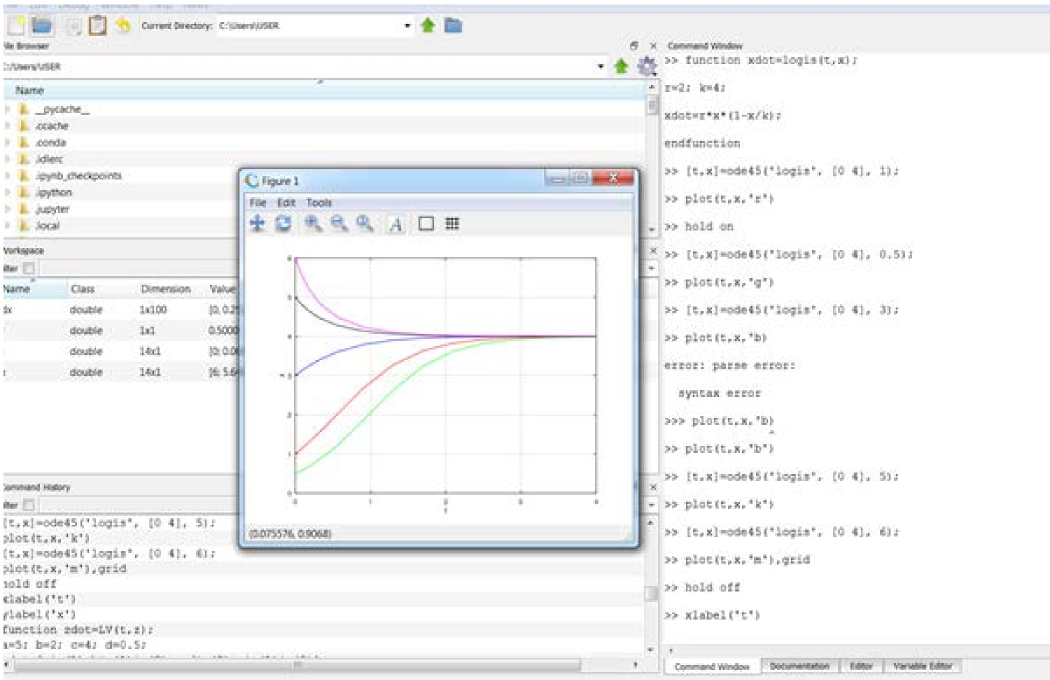

Figure 12: Solution of Logistic Model

3.3. In Fig 13 and 14 we have shown the solutions of Lotka-Volterra Equation as functions of time and in the phase plane

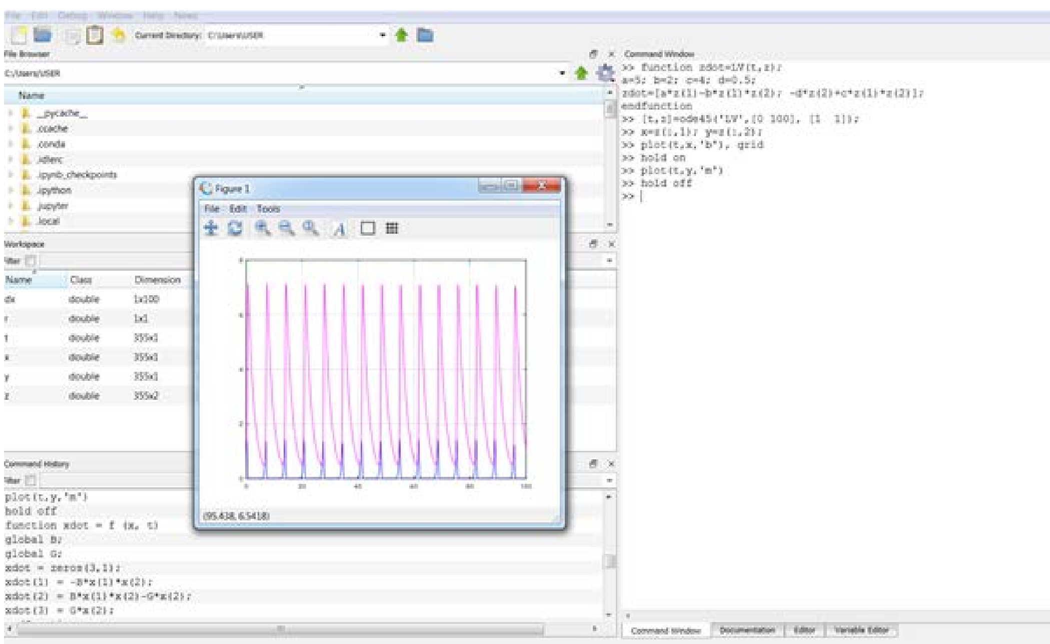

Figure13: Solution to the Lotka-Volterra Predator-Prey Model as Functions of time

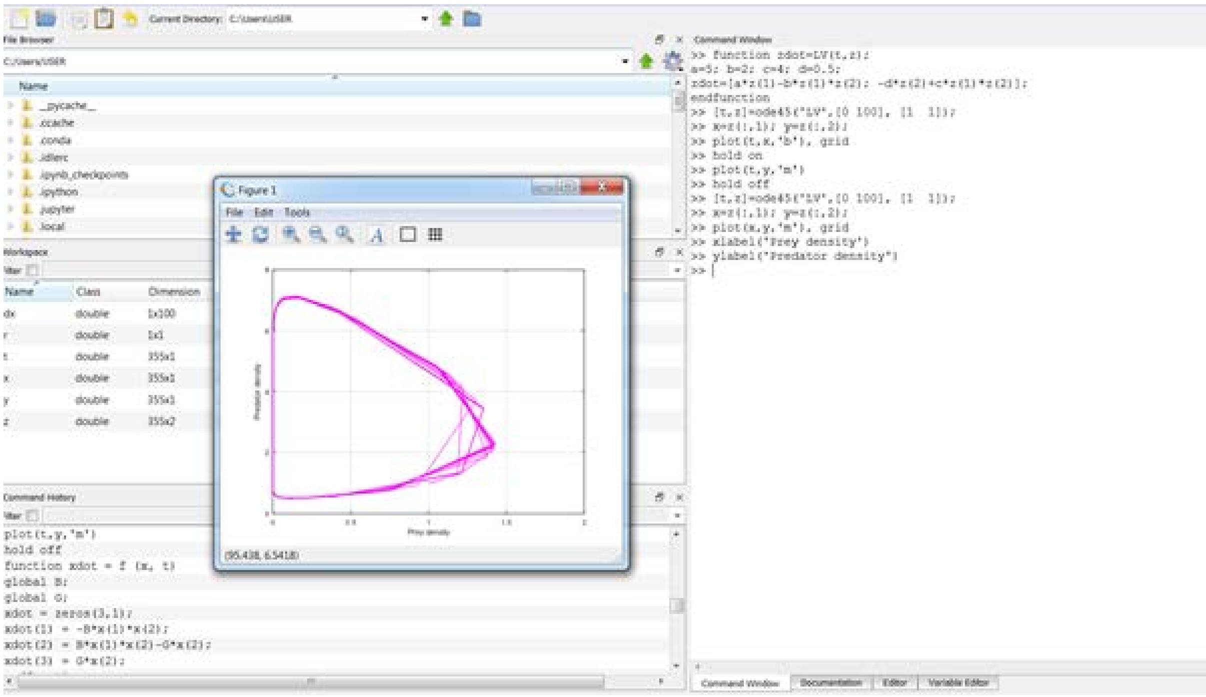

Figure 14: Solutions to the Lotka-Volterra Predator-Prey Model in the Phase Plane

3.4. In Fig. 15 we have given a numerical simulation of the famous SIR epidemic model and also plotted the solution curves.

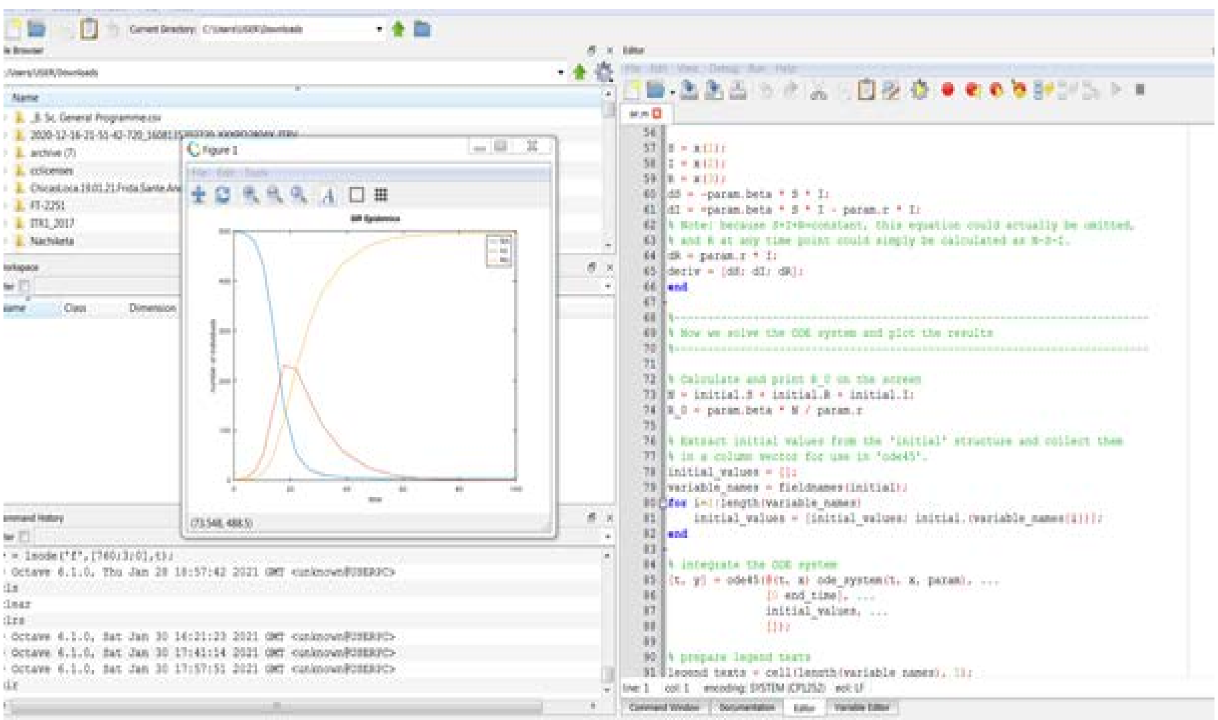

Figure 15: Solution of SIR Epidemic Model

CONCLUSION

Online (or distance) learning has become an increasingly important part of educational programs. In the 21st century Educational institutes are extending their digitally linked resources and providing a flexible delivery of content material. Use of technology supports learning process when integrated with teaching pedagogy, curriculum, and assessments appropriately. We have shown the benefits of introduction of free open source mathematical software into teaching and learning process. Students, from any level of mathematical knowledge can be encouraged to study mathematics by using these applications. Current trends in the teaching of science call for the use of visualization techniques, and these free open source software fit perfectly this trend.

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Chapter 7

Concept Mapping in Science Education

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Concept Mapping in Science Education

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ABSTRACT

A concept map is an institution of visual display and knowledge based representation. It shows the relationship among various concepts and ideas. It is a graphical representation i.e. a kind of diagram of knowledge of some typical domain. In one word, it is a method to understand the relationship between different theories and concepts. This technique initializes with a question or idea, and then adds arrangement with related topics, synonyms, keywords, and examples. This technique may be helpful in making relationship between different ideas. It helps ocular learners to understand the material. It also helps students to evaluate the assumptions.

Keywords: *Concept Mapping; Students; Teachers; Questions; Diagrams; Assumptions*

INTRODUCTION

Teaching the science subjects in schools and colleges is both effective and demanding. Forming an encouraging learning environment with a science-rich curriculum that engages all students is of great demanding. Checking the progress of students as well as knowing that they understand the science concepts, teaching can be irresistible. How can we realise if students develop a scientific method of the important concepts? Is it possible to produce a picture of this understanding? In this article we address these questions by using concept mapping.

Definition

Concept mapping is a best way to build upon former knowledge by connecting new information. A concept map is an institution of visual display and knowledge-based representation. It shows the relationship among various concepts and ideas. It is a graphical representation i.e. a kind of diagram of knowledge of some typical domain. In one word, it is a method to understand the relationship between different theories and concepts. This technique initializes with a question or idea, and then adds arrangement with related topics, synonyms, keywords, and examples. This technique may be helpful in making relationship between different ideas. Concepts are drawn as nodes and relations are drawn with lines that are drawn between associated concepts. It is a contrivance technique that visualizes the different ideas and concepts. This conceptual diagram is a diagram that depicts suggested relationships between concepts (Hager *et al.*, 1997). Concept maps may be used by engineers, technical writers, pedagogical designers, and others to organize and frame knowledge.

It typically represents the ideas and information as boxes or circles, which it connects with labelled arrows, often in a downward-branching hierarchic structure (Figure 1).

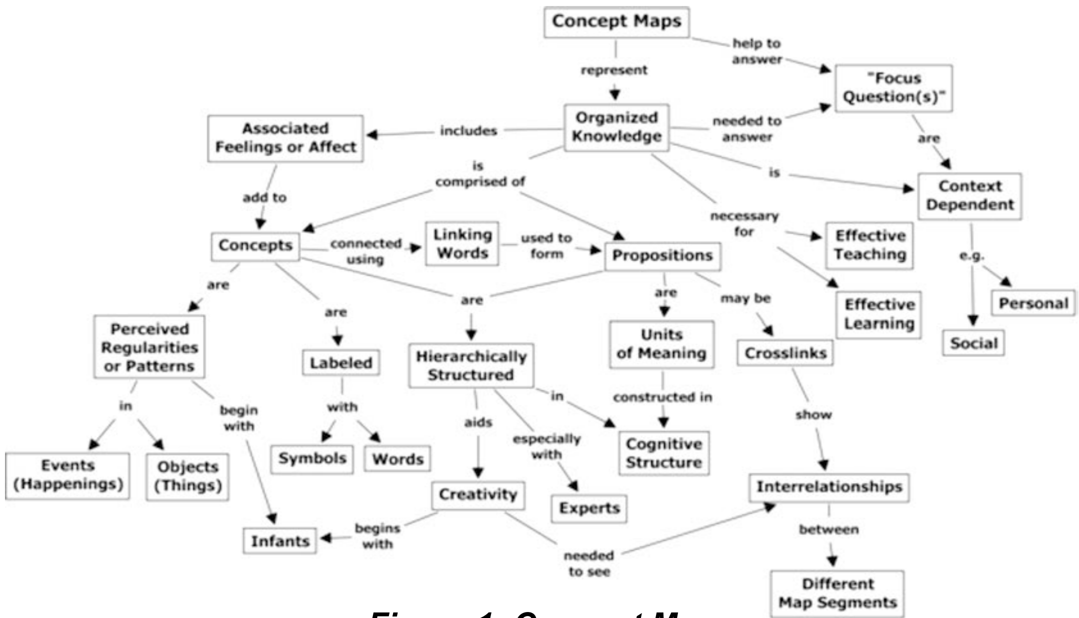

Figure 1: Concept Map

Concept maps have been used to define the philosophy of computer systems. This map is a way of representing relationships between ideas, images, or words, in the same way that a road map represents the locations of highways and towns. In this map, each word connects to each other, and links to them. It is a way to develop rational conception and expertness of study by declaring connections and helping students to see how individual ideas form a bigger whole.

This map increases the significance of learning in the sciences. This grows within a certain frame defined by a specific question, while a mind map often has only branches regarding a central picture. Some research publication suggests that the brain is the fund of knowledge that acts on declaratory memory unit, which is also referred to as offering.

REVIEW OF LITERATURE

History

It was developed by Joseph D. Novak and his research team at Cornell University in the 1970s as a means of describing the knowledge of science of students (Novak, 1970). It has been used to increase significant learning in the sciences and other subjects as well as in government, education, and business sectors.

Novak's work is based on the cognitive theories of David Ausubel, who gave importance of previous knowledge to learn new concepts: ‘The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly’ (Anderson & Lebiere, 1998).

Various attempts had been made to realize the process of creating concept maps. Ray McAleese has suggested that mapping is a process of off-loading which is shown in a paper, McAleese draws on the work of Sowa (Anderson *et al.*, 2004) and a paper by

Sweller & Chandler (Novak & Gowin,1996). In a word, McAleese suggests that for better understanding, using symbols and relationships, the individual should aware of what they know and what they able to modify. Maria Birbili applied same idea to help children so that they can learn to think what they already knew and what to yet know (Ausubel *et al.*,1968).

Differences from other methods:

- Topic maps: Concept mapping is very much close to 'topic maps' as both methods connect concepts or topics through graphs. Concept mapping is unique in its philosophical point, which creates concepts, and offering composed of concepts.
- Mind maps: Both concept mapping and topic maps can be built up with mind mapping, which is often limited to tree structures. Another difference between concept mapping and mind mapping is the spontaneity. A mind map reflects what one think about single topic, which could emphasis on group brainstorming. A concept map may be a set of concepts. It is more free shape, as different focus and bunching can be created, unlike mind maps, which typically emerge from an individual point.

Advantages of concept mapping:

It has several advantages:

i) Ocular symbols are easily and quickly acknowledged

ii) Minimum use of text makes it easy to the general idea

iii) Ocular presentation helps for development of a holistic reason that words alone cannot carry

iv) Use a concept map to construct and organize one's ideas and find connections that might never occurred before to one

v) It helps ocular learners to understand the material

vi) It helps students to find familiarity between concepts and ideas

vii) Taking advantages of the full range of the right and left hemispheres of the brain

viii) Helps to recall the memory

ix) Helps to refine structure and ideas

x) Create, analyze, and evaluate the ideas

xi) Helps students to develop and fulfil the ideas, information and concepts

xii) Encourages students to invent the inner meaning of subject

xiii) Self-evaluation of students

xiv) Helps students to assess the ideas.

Application of concept mapping:

(1) **Creativity tool:** To draw a concept map can be compared to participate in a brainstorming method. When one writes down the ideas on paper, it becomes obvious for mind to receive new ideas. These new ideas can be joined to that already on the paper. They may also target new associations giving to new ideas.

(2) **Hypertext design Tool:** As the World Wide Web becomes an increasingly

powerful tool for disperse information; writers must move from writing text in linear fashion to hypertext documents. The structural relationship between hypertext design and concept maps makes this mapping an appropriate tool for designing the theoretical structure. The structure of both a concept map and a hypertext document can be seen as an educational graph (Sowa, 1983).

(3) **Information tool:** A concept map represents one possible way to develop information or idea. It can be used as an information tool for people to discuss concepts and the relationships between the various concepts.

(4) **Knowledge tool:** New information should be mobilized into remaining structures in order to remember and accept the meaning. Concept mapping augments this process by put the learner to give attention to the different concepts. Thinking is the most important condition for learning and students represent their best thinking when they show something in graph. This mapping is also an important tool for problem-solving in system of education. It may be used to give variable answers and choice. Since, in education, solving the problem is usually done in small groups, learning should be also benefited from this mapping.

(5) **Assessment tool:** This mapping can be used as appraisement tool. The idea of students may often incomplete and insufficient leading to misunderstanding of information. This mapping expresses their conceptions or misconceptions and can help the teacher to diagnose the misconceptions that make the idea insufficient (Sweller & Chandler, 1991).

Use:

Concept maps are widely used in education, business and government sector. Uses include:

i) Creation of new knowledge, in other words, transforming silent sense into an organizational mode

ii) Knowledge preservation of institute, inventing and mapping specialist knowledge of employees

iii) Modelling of collaborative study and the transfer of specialist knowledge

iv) Simplifying the generation of shared view and reasoning within a team

v) Notifying complicated ideas and reasons

vi) Inquiring the consistency of complicated ideas and terms

vii) Describing the entire structure of an idea for the scrutiny of others

viii) Betterment of ability of language

ix) Assessment of learner's reasoning of learning concepts and the relationship among these various concepts (McAleese,1998).

x) These maps are paths for representing and organizing the various knowledge. They cover various concepts, usually represented in circles or boxes. Linking words on the line mark the relationship between the two concepts.

xi) The presentation of main concepts from a text into a visual arrangement. Lines are drawn between similar concepts, and relationships between the connected concepts are named. This mapping expresses the structural model and gives the whole picture.

xii) This is a technique for understanding the relationships between various concepts. This is a diagram showing the relation between various concepts. Concepts are connected with labelled arrows.

Implementation of concept mapping activity in classroom:

Step 1—at first, the students are trained up to use this map. We have to provide students with a practice topic with which they are quite familiar (science related), if they have never created a detail of concept map. In this study, the concept map activity was the unit on density showing in Figure 2. For training purposes, teacher should give the student an example on a non-science topic also to practice it.

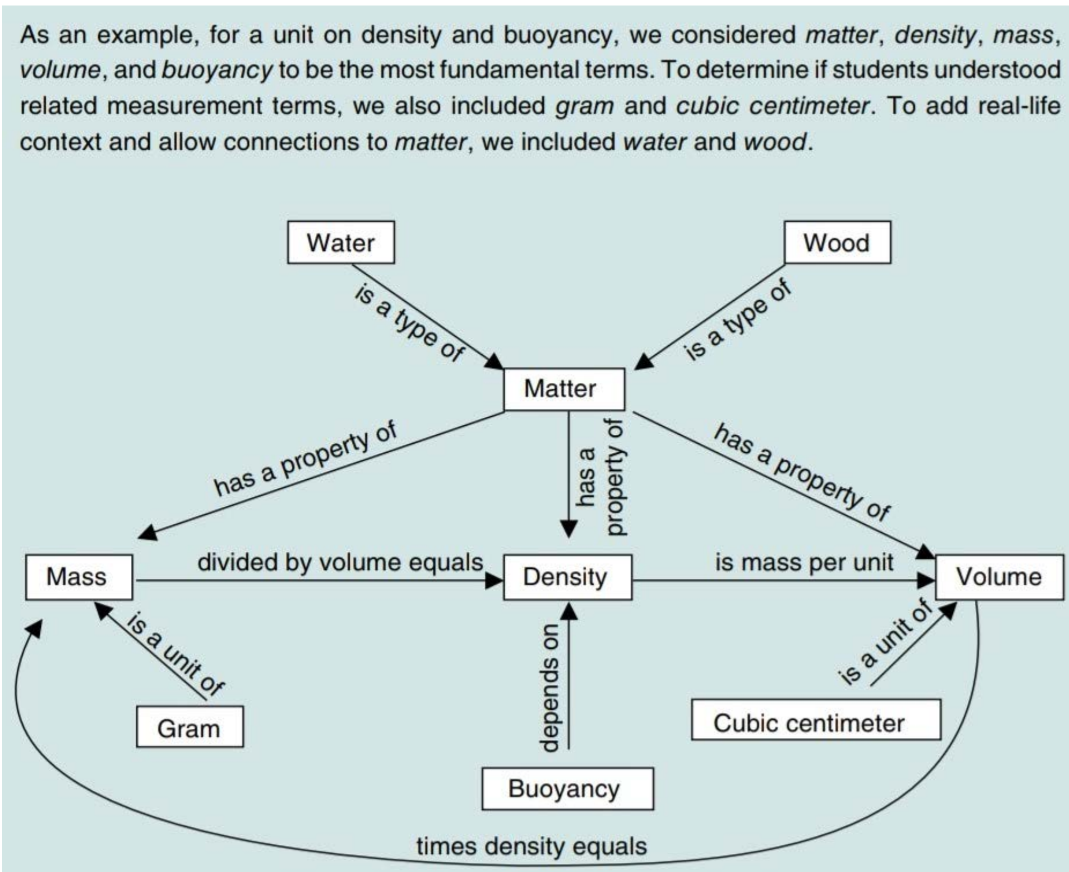

Figure 2: Implementation of Concept Mapping Activity in Classroom

Step 2—Then, teacher should ask students to generate their own separate maps. This distinct reflection position is very important; it reflects the individual understanding of each student. It is found that, without completing individual mapping, formation of a concept map as a step of class activity is very time destroying and not attractive for all students.

Step 3—next we can review the maps in small groups. After students can finish their own concept map, teacher should organize small group discussions on it. Then they were asked to search similarities and dissimilarities in their maps and try to reunite them. Group discussions give scope for students to engage in the social prospect of science, where they can share their thoughts and know from each other.

Step 4—We discuss the whole class of the small group about the concept maps. We ask each group to represent their important ideas to the whole class. Many proposals are discussed, but one should focus on those that are more related with to what one want to know about the students' level of reasoning. A whole-class based map can also be prepared depending on students' discussions. Assessing concept maps without record, one would find that concept maps are very informative. A fast scrutiny of the maps will show that what students are thinking, which will in term help one to generate ideas for improving students' thinking. In some cases, teacher may evaluate students' maps. By choosing the important science terminology from teaching curriculum, a concept mapping can be a used as a powerful assessment tool.

CONCLUSION

In general, concept mapping give a different aspect on student intellect that complements selected-reaction and performance-based documents. For knowledge of students' thinking about science, a cordially designed concept map activity can be an excellent way.

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Chapter 8

Understanding the History and Philosophy of Chemistry is the Cornerstone of Chemistry Education

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ABSTRACT

History and philosophy of science in Chemistry education have had conventional applications which have focussed on the teaching and learning of "History of Chemistry". For many decades now, teaching of science has been done through the adoption of the historical approach. Since this method stresses on the products of science as well as the evolution of its ideas, theorists say that this approach can enhance students' comprehension of the nature of science. On the other hand, "Philosophy of Chemistry" has emerged as a separate arena and has explored the inferences of philosophy of chemistry for chemistry education. This chapter portrays the importance of "Philosophy of Chemistry" and the "History of Chemistry" towards chemistry education.

Keywords: *Chemistry; Education; History; Philosophy; Pedagogy*

INTRODUCTION

Knowing the history and philosophy of any particular subject in science is an essential component of science education and recently it has garnered wider interest. Chemistry occupies a central position in science and it helps students to pursue a career in fundamental research, medicinal chemistry, industrial chemistry, food science, engineering and other related disciplines. Countless students have misconstrued approximately how chemistry expertise has spawned over time. Teachers of science ought to be thorough with the history of chemistry to facilitate the dispelling of these misconceptions. Students are offered with a practical photo of clinical research that strengthens their knowledge of the character of science when instructors can give an explanation for the history of scientists who have discovered new areas in science despite hindrances, have got this assistance and collaboration from compatriots to solve intricate problems and have developed upon their designs. This short history of chemical education suggests that history of science can influence the teaching of science solely when the desires of historians and the dreams of scientists are in agreement. Bequeathing students with theories without making them gain scientific inquiry thereby hindering the processes of constructing these principles is the tradition.

In particular, rarely do we see students being facilitated in the formulation, comparison and revision of scientific knowledge. Often, when learners attempt to explore new territories in the chemistry laboratory, it tends to happen as pursuits of an already treaded path and is not consultant of chemical analysis that inspires chemists to chart new territories. The method of growth of chemical knowledge can be promoted at the level of the lecture hall by enhancing one's knowledge about 'Philosophy of Chemistry'. It is a novel arena that purports to apply philosophical themes in chemistry education.

This chapter encapsulates the 'History of Chemistry' and recent emergence of 'Philosophy of Chemistry' to aid in the learning of chemistry.

REVIEW OF LITERATURE

History and philosophy of chemistry and chemistry education

One cannot find a broad intersection of chemistry education research and the application of history and philosophy of science (HPS) to science education (Kauffman, 1989) Most chemists show little or no interest in the history of chemistry and that is what has led to the establishment of the anti-historical way of teaching of the subject (Brush, 1978). This interpretation makes way for an overlap of the position of chemistry education research with the position of the historical and philosophical extents of the subject of Chemistry. There have been several chemists who have added to analyses of their discipline from a historical perspective. Experts in the subject like Kopp, Thomson, Berthelot, Ostwald and Ihde have been intimately involved in highlighting the necessity of chemistry and its history. It is said to be as early as the 1930s when inclusion of history of chemistry in chemistry teaching began as a practice in the United States to chemists (Jaffe, 1938 & Oppe, 1936).

The prime reason of this inclusion is to enhance curiosity and inquisition in students by showing them role models through the enumeration of varied events from the lives of renowned chemists. Many a time, it is found that history of chemistry is created by chemists from the viewpoint of current standards and measures. Moreover, this enumeration of historical accounts of the subject is usually founded on the affiliates' interpretation of chemistry. An affiliate's interpretation includes instances of investigational findings. It is more effective to stand by the outsider's interpretation of history of chemistry: a scrutiny of historical trials without accepting them literally.

According to the account of chemists, oxygen is said to be natural whereas phlogiston is considered imaginary. However, such categorizations are inadequate as compared to historical elucidations. In the eighteenth century, nobody accepted oxygen without questioning its existence. The necessity is therefore the clarification of the argument on oxygen among eighteenth century chemists. The chroniclers need to scrutinize the collective and individual issues to clarify the procedural experiments of chemists. The fact that pupils enter the chemistry lecture hall not as fellows but as outsiders is what applies directly to chemistry education.

Notwithstanding the fact that history of chemistry is now being included as a part of academic courses, theoretical scopes of chemistry are still quite unexplored (Van Brakel, 1994). Certain dominant queries in philosophy of science, such as the aspects of science as opposed to diverse activities, have been conventionally lectured through physics, also known as paradigm science. Although the stress on the rational examination of scientific philosophies has been questioned by theorists such as Popper and Kuhn, the bequest of logical positivism as well as supremacy of physics in logical studies continues to remain.

A strong reason that repressed the progress of chemical epistemology was reductionism. If one is to look at it with a viewpoint that is both logical and positivist in nature, one can say that chemistry is reducible to quantum mechanics which is the storehouse of theoretical problems of science. This action of the lessening of one science to another was contended in keeping with correlation and derivation of laws in all these sciences. Thus, many chemists and historians of science have challenged the idea of chemistry being a reduced science.

Philosophy of chemistry: an emerging field

More and more people are showing a growing concern and sheer curiosity about the analysis of chemistry as a single subdivision of science. A budding assembly of theorists of science have underwritten the design of the novel arena, philosophy of chemistry which was the subject matter of the first international conference on 'Philosophy of Chemistry' in 1994. The American Chemical Society, in 1997, conducted its annual meeting to discuss matters contiguous with the interaction of philosophy and chemistry. The principal problem of a new-fangled journal, Foundations of Chemistry, devoted to philosophy of chemistry, was published in February 1999.

Since 'Philosophy of Chemistry' is a developing arena of chemistry education, it is quite expected that literature of science education has scarcely spoken of the uses of this arena in chemistry education (Novak, 1984). A lot of exploration is required to bring into line chemistry education with fresh viewpoints on chemical epistemology. Prototypes and demonstration of the same offer a critical and pertinent background that influences philosophical features of chemistry to be used more broadly in the classroom.

Representations and modelling in 'philosophy of chemistry'

There is extensive indication that youngsters study and use representations from the initial stage of learning chemistry. Youngsters' education through use of models in the schoolroom has been endorsed on the basis of the fact that models can act as "integrative schemes" (National Research Council, 1996) understanding students' varied experiences in science across grades K-12.

According to the National Science Education Standards in the United States: "Models are tentative schemes or structures that correspond to real objects, events, or classes of events, and that have explanatory power. Models help scientists and engineers understand how things work. Models take many forms, including physical objects, plans, mental constructs, mathematical equations and computer simulations" (NRC, 1996).

Taking into consideration the stated principles, it is essential to assess how representations have been used in the chemistry classroom. On testing the employment of chemical representations in teaching, we tend to observe many tendencies that recommend absence of backing for understanding of representations and modelling by learners. First, chemical representations are conferred to learners as ultimate forms of our evidence of material: duplicates of actual molecules in distinction to estimated and approximate depiction. The inspirations, ways and opinions fundamental to the event, examination and modification of chemical models usually point at the employment of models for abstract differentiation.

An example that can be cited is that models are used to differentiate between density and weight as well as temperature and heat. Again, we often do find a categorical division between chemical models but often pose 'hybrid models'.

We can also say that, chemical models are tantamount to ball-and-stick models which are characteristically employed as visual aids. These 'physical models' have been envisioned to increment theoretical knowledge and their application has been vindicated on theories proposed by Piaget who stated that scholars in actual effective junctures require real models to comprehend the arrangement of molecules (Battino, 1983).

Lastly, historically, chemical information schooled in discourses has been perfected by laboratory investigation that is expected to supply learners with the chance to establish chemistry as investigation. Chemical testing, however, has seldom been translated within the academic atmosphere as an action through which models are created, assessed and revised. Relatively, research is frequently made obligatory through collection and clarification of information. Proof indicates, however, that instructive representations might not be created from information obtained in laboratory events if specific creation of such representations is usually not accepted.

In the lecture hall, the 'cookbook problem' i.e. blind following of 'recipes' is persistently camouflaged as conducting chemical tests. Chemistry that is the science of matter is neither determined just by guidelines, nor by information gathering and analysis alone. Chemists add to the growth, assessment and modification of chemical knowledge. For efficacious education of chemistry, schoolrooms need to model the arrangement and purpose of matter by highlighting the role of chemists in the process.

Course on the history of chemical discoveries

It would not be wrong to assume that the history of chemical detections ought to be planned and made accessible to employed and trainee science instructors to offer an all-inclusive evaluation of the chemical detections and the historical framework in which chemists made them. This development ought to reconnoitre how principles of chemistry are shaped and reread, thereby re-establishing the nature of science. When instructors are aware of the history of chemistry, they are even more accomplished to “(1) enrich the presentation of scientific knowledge and (2) emphasize the tentative nature of scientific knowledge.” When we add this matter to the novel national ideals of teaching chemistry, it licences pertinent preparation and proficient expansion to aid educators to meet these ideals. Therefore, it is an earnest request to our compatriots to imbibe and apply relevant curricular augmentations for secondary level teachers of science with the intention of accomplishing job-oriented necessities of expansion through coursework or the pursuit of a high degree. Thus, instructors should be able to fulfil both their necessities related to licensure and principles delineated by the Next Generation Science Standards.

The aims of the curricular framework should be quantifiable and encourage higher-order thinking. At the end of a fruitful accomplishment of this course, the members of the same are expected to be able to:

(1) Scrutinise social tenets and their impact on research in chemistry across varied periods of history.

(2) Debate over the socio-political repercussions of research in chemistry and growth of chemistry knowledge across ages.

(3) Evaluate the effect of anthropological relations on scientific ventures.

(4) Elucidate how the change of history as made to happen by chemistry and foretell its continuation of the same in the future.

(5) Classify the reasons behind the fast incorporation technology into everyday life by equating previous and current incorporations of technology and foretelling the scope of the same in future. Curricular material must review a range of chemistry throughout history.

It is necessary to include a model course outline with recommended divisions and topics (Table 1). This list gives an idea about the potential topics for a history of chemistry course or components to be incorporated into a course that already is in place.

T*able 1: An Overview of History of Chemistry Course*

Unit	**Suggested Topics**
The Chemistry of War	The first World War The second World War The Cold War
Ancient Alchemy	Alchemy in the East: India, Japan and China Alchemy in the West: The Roman Empire and Medieval Europe
Physical Chemistry	Nuclear Chemistry: Marie Curie and the Manhattan Project
Inorganic Chemistry	Blomstrand-Jorgensen Chain Theory vs Alfred Werner and Coordination Theory Fritz Haber/Nitrogen Fixation
Organic Synthesis	Synthetic dyes and pharmaceuticals Determining structure and function: Chirality, benzene, DNA, etc.

CONCLUSION

Learners' misapprehensions about the beginning of chemistry knowledge can be corrected by means of proper training in the history of chemistry. In addition to this, learners can obtain a better general comprehension of the nature of science from the viewpoint of history. Thus, enlightening educators about the history of chemistry will allow them to elucidate that scientific philosophy and training have advanced with the passage of time. The philosophies defined here recommend an approach for training committed educators to add historical trials and viewpoints to their schoolrooms, thereby augmenting a pupil's learning of chemistry.

In this chapter, an attempt has been made to enable students to immerse in the knowledge of chemistry and its history when they are given the chances to improve and apply the very principles and methods that incite and authenticate knowledge prerogatives of chemistry.

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Chapter 9

Skill-Based, Problem-Based and Research-Based Learning

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Skill-Based, Problem-Based and Research-Based Learning

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ABSTRACT

For surviving in 21st century, some innovative approach to learning is required, which enables students to adapt critical thinking, apply their knowledge and to work in collaboration for the creation of new projects with better and sustainable outcomes. Problem-based, skill-based and research-based learnings are student centered techniques which provides them with a larger opportunity for independent approach to various problems, thus making a room for more innovations. The need of the hour is to shift the rapid flow of globalization towards the more efficient learning processes. Now a days, higher education curriculum gives immense importance to capability development, life oriented and learning paradigm rather than work oriented and teaching paradigm. This shift would definitely require innovation in the learning process and student learning experiences. This study shows that introducing and implementation of models like skill-based learning, problem-based learning and research-based learning increases the quality of learning. There are more chances of innovation along with the better credibility.

Keywords: *Skill Based Learning; Problem Based Learning; Research Based learning; Innovation; Critical thinking; 21st Century Skills*

INTRODUCTION

Today's technology has affected the way human live and work drastically (Lau, 2018) and has remarkably shifted the traditional educational paradigm towards the internet of things (Khan *et al.*, 2018; Kurniawan *et al.*, 2019 and Sulistyo *et al.*, 2019). In life-based learning, the learning activities are implemented through various characteristics like social skills, thinking skills, everyday experiences, interdisciplinary, and trans-disciplinary, learning more dynamic and flexible responses. Furthermore, in such approach, students act as organisms and sources of knowledge with collaborative learning. In today's scenario, the need of the hour is the type of learning that is able to explore the new ideas from students (Mustofa & Hidayah, 2020). Dewey emphasized on the idea of "learning by doing". He stated that the classroom should be a kind of society where students should be encouraged to be the center in the learning process (Du & Han, 2016). Such type of approach to learning is a student driven and teacher facilitated. Teaching for higher education requires to train students with skills of a broad spectrum required in innovative and varying knowledge societies and economies. Moreover, to subject-based know-what and know-how, this embraces skills for creativity along with behavioral and social skills.

REVIEW OF LITERATURE

The parallel pillars: skill-based learning

Skills plays a major role in the overall personality development of an individual. Skill based learning or skill development refers to either acquiring of skills or enhancing of existing skills to the level which is parallel with the ongoing work front. Skills are very important as they make us more familiar with the work and allows us to know the topic on conceptual grounds too. They make us confident and independent, leading to the enhancement in our credibility and critical approach (Erdogan, 2015; Prince, 2004). We must be self-sufficient in at least understanding tools that are related to our work. The responsible body for the coordination of skill development activities in the country is the Ministry of Skill Development and Entrepreneurship (MSDE). Organizations like National Skill Development Corporation (NSDC) has established various institutes for the promotion of skill development in the country. Skill-based learning includes planning, implementing, and analysing of the skills acquired through knowledge-based learning methods. Students are motivated to think logically, analyse concepts, and apply their insights. In today’s scenario, multitasking is not really an option, it is the necessity, and one must acquire this skill by getting involved in such projects whose demands are different at different times.

Importance of skill-based learning:

- **Develops critical thinking-** Allows students to own analytical and critical thinking in all aspects. It creates a way for avoiding the simply mugging of facts rather focus more on synthesising, evaluating, and applying facts and ideas while solving the problem.
- **Spark’s creativity-** It offers a way to proceed beyond traditional methods and think innovatively.
- **Enhancement in collaborating problem solving-** Working in a constructive manner is an important aspect and skill-based learning provides a room for the same. Overall better communication- articulate discussion, active listening and presentation skills help in the improvement of communication skills.
- **Leadership quality-** Having the approach to think above our self-interests is one of the important qualities of being a leader. Skill development program helps in the cultivation of such qualities.
- **Adaptability-** Having the comfort zone with each working environment is not always possible. But if we know the skills that are required to go through any process then we can easily make our way.

Skill based learning guides the learner through a reflection on their learning. ***Education is important, but skills are necessary***. Skill is unarguably the dire want of the hour as it enables the person to contribute extra effectively to a particular field. As generally observed, those who have skill-based total schooling are higher learners as they have learned from experience, so they generally tend to conserve including inputs to their know-how bank. Thus, for them, the mastering process never stops. Skill acquiring is not a technique, it is the fundamental art of survival in today's fast-growing world.

Problem-based learning

Great and successful learning is not only about the memorization of important facts, but also more about the ability to create new pathways and then finding better solutions through critical thinking approach. This provides a room for a good alternative to traditional approaches by transferring the significance from what is taught to what the student understands, ensuring better understanding of the concept. With traditional approaches, there is a high risk of noticing only the eye-catching superficial features of a problem rather than understanding its structure beneath. Instead, learning environments, where students are able to make use of their education and understanding for providing solutions to real life problems, has to be created by the education system. Along with the appropriate discipline-specific knowledge, problem-based learning helps in developing of transferable skills as well, which plays a very important role in today's scenario. In vocational education, development of hard skills and soft skills dominates the learning characteristics (Nurtanto, 2020). Question-based and student-centred PBL approaches facilitates adult learning theory along with reasonable and social constructivism (Widayati, 2010). This makes learning as a self-reliant and an active process where students work together in groups to deal with the complex practical situations.

Key components of PBL as identified by Barrows.

- Students are given with unresolved problems, so that there can be a generation of more than one solving approach on which ultimately students will have to work. The idea is just to grab student's attention towards various possible multiple solution routes.
- An approach which is student-centered, focuses on students determining what they need to learn. It depends on the learners to procure the crucial issues of the problems they face, define their knowledge space, and pursue and gain the lacking part.
- Teachers play a key role in being the mentor to the student's learning process. Though while lecturing, tutors waive about the content helping in exploring different types of learning processes that account to success in the setting of PBL.
- Authenticity comes when there is a tackling to real world problems with reasonable solution driven pathways. Usually, problems are inter-disciplinary and thus for getting a workable solution, student needs to probe multiple subjects.

Over the time, the concept of PBL has advanced, focusing engagement of students, interaction as well as tailored scaffolding for better understanding of students. As said by Schmidt, Loyens, van Gog and Paas, PBL works on instruction basis with elements that provide a room for flexible adaptation of guidance compatible with humans' cognitive architecture. Students incorporate accountability with PBL, by writing about their daily goals (Bell, 2010). Long term recognition of knowledge for students of higher education clearly reflects the benefits of problem-based learning over the traditional ones. Though students with PBL approach may be moderately subordinate to traditional students in all-inclusive knowledge and competence, but they do appear to be supercilious in long-term recall and retention.

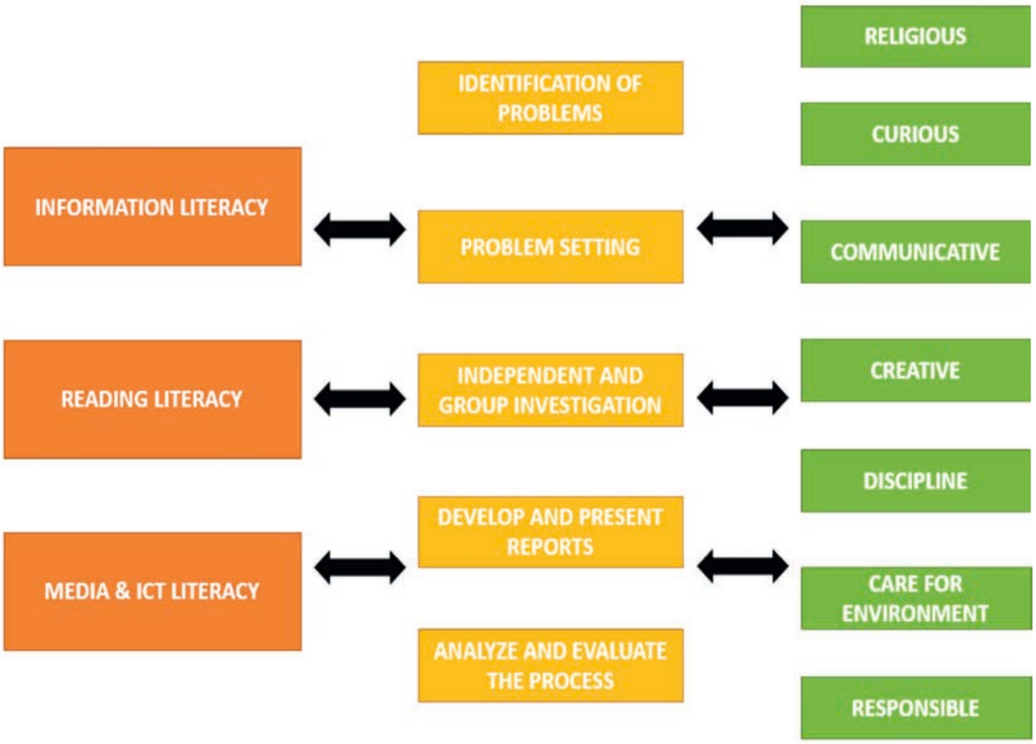

Figure 1: Learning and Innovation skill in Problem based learning

Research-based learning

Research is a prime way of enhancing learning quality. Learning is a process, not a product. This involves a change in knowledge, beliefs, behaviours and/or attitudes and then only we will be able to create something new, something original. Research includes having the fundamental knowledge and then applying that knowledge for finding the better and more effective solutions to any problem, which is possible only when we have the ability to think beyond the written text. Research based learning can be broadly confined as the approaches of inquiry-based learning, which can be compared to an umbrella's structure covering a wide array of approaches that helps in effective learning that are pushed by an action of inquiry. So, it would include the idea of problem-based learning, project work, field-exercise, case studies etc. Research based approach involves:

- Understanding the epistemologies and forms of discipline-based inquiry.

- Getting to know about specific research methodologies with respect to different disciplines.
- Relating the questionnaire and forms of inquiry linking directly to faculty member research interests and crux of the present research in the disciplines.
- Creating a working atmosphere that reflects more towards the knowledge creation pathways and circulation in respective disciplines along with the professional areas.

Research based programs should be introduced in every school regardless of affiliation and syllabi, in order to furnish them with the skills needed to flourish in the 21st century. This presents a substitutive learning model that facilitates analytical thinking skills. Research at the basic level, is all about the originality of an idea, its implementation and possible working pathways. Some variation has to be there from the already reported fact, whether small or big because that is only responsible for generation of a fresh effective idea. Research based learning is a system, consisting of instructions which are used for an authentic learning, cooperative learning, problem solving and hands on outlook, further directed by a constructive philosophy. The system provides opportunities for students to explore their potential in adjusting to their needs and giving them the experience needed for their lives in the future (Ratnawati & Idris, 2020). Innovation is the most required attorney for the better grip of future and research-based learning is the root for the gateway. Thus, this approach should be introduced at most of the levels, wherever possible for maximum contribution towards the sustainable development.

CONCLUSION

Skill development process is crucial for both personal as well as professional front. Skills like communication, networking, team spirit and adaptability creates a room for overall development of a person which ultimately leads to the better outcomes. This aids for the more stable future as skills learned allows students to get familiar with employability-skills at a very young age and thus creating a room for exploration of vast options. Process of skill-based learning ensures the proper development of student, which is must in today's high demanding atmosphere. Savery defined problem-based learning as “an instructional (and curricular) learner-centered approach that entitles learners to direct research, integrate theory and practice, and put in knowledge and skills to develop a feasible solution to a defined problem”. So, giving students the sufficient guidance and structure regarding committed educational goal, should be an inherent part of productive PBL. This may include making students familiar with high quality problems, engaging them with small group collaborations or simply scaffolding the process to encourage self-governed learning. Overall, one of the most researched pedagogical revolutions in education has been PBL only. Recent studies have shown that PBL also helps in the cultivation of better interpersonal, communication and teamwork skills too. Mastering a wider range of skills will allow students to become a true learner and that too for a lifelong, they will be able to face and act accordingly towards the uncertainty of the future. Such skills for innovation, in addition with higher learning approach, are getting more and more attraction worldwide. For innovation in any field, creativity and independent thinking forms the backbone and these two can't be just memorised! These are the skills which one can only develop by being in the environment where they are able to use their learnings and independent thought process for figuring out any real-life situation. Thus, skill-based learning along with the problem-based learning are like the two pillars of a gate for research-oriented studies and these three together forms the gateway for a bright future.

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Chapter 10

Science and Legal Knowledge with Special Reference to IPR

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Science and Legal Knowledge with Special Reference to IPR

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ABSTRACT

In general, to block competitors from entering the market space, whenever a company or an individual innovator discovers a commercially viable technology, the next step is to secure legal protection, which is not a minor task, as many innovators and companies realize. Due to the rise in the rate of discovery, as a direct consequence, legal freedom decreases. However, to take these legal steps for securing one's intellectual property, legal knowledge is a necessity and the knowledge of how to use their intellectual property rights which primarily belongs to the area of technological and scientific innovation. The protection of ideas and the written expression of ideas should concern all innovators as they regularly use laboratory manuals, copyrighted journals, trademarked and patented products. Acquiring the copyright and then transferring it to journals and book publishers are the norms, which every author has to follow. On the other hand, in their employment to their employer, Innovators and Scientists in academia or industry are generally required to transfer all inventions. The true success of Science, ironically, is limiting rather than extending its autonomy. The involvement of Science with various partners leads to claiming ownership rights by each of them to their intellectual property. Therefore, Legal knowledge of IP provides a solution to various conflicts and a policy framework that allows the transformation of intangible resources into sustainable development assets by promoting and protecting innovation and creativity, which will eventually help innovators cultivate Science fruitfully.

Keywords: *Science Policy; IPR; Intellectual Property; Legal Knowledge; Innovation; Technology*

INTRODUCTION

Science is similar to all other sapiens activities: a socially constructed phenomenon – the brainchild of our decision-making capability and mutually organized human labour that involves competition, debate, and struggle. The need to motivate inventors to bring novel and applicable products to the marketplace for the utility of all was recognized by society ahead of time and therefore, safeguarding and rewarding the innovator for his expensive, time-consuming, and valuable research, the protection against infringement done by competitors and their colleagues (most of the time) is necessary. Intellectual property is the engine of creativity, and the backbone of creativity is the cross-pollination of ideas. As innovators are given the incentive to come up with ideas and are willing to patent and publish their work, therefore, the protection of ideas and written works becomes essential, and for that, a person working in the field of Science should have legal knowledge so that he would not get deceived. Creativity, creation, and innovative application of state-of-the-art knowledge are the most critical assets in global competition. The scientific community is their primary source (Straus, 2004; Zuckerman, 1988). Therefore, this source requires appropriate financial support and the necessary knowledge of their intellectual property rights to perform correctly.

REVIEW OF LITERATURE

Intellectual property and intellectual property rights

The protection of the expression of ideas in the form of copyrights, patents, and trademarks by the creators of such ideas lead to the formation of a generic legal term called "Intellectual property" (IP) and the legal rights known as Intellectual Property Rights (IPR). IP is an intangible property. A property which, even when "taken away," remains in possession of its original owner whereas IPR is a series of principles and rules to protect intellectual achievements, whose goal is to endow an organization with the authority or legal position to encourage knowledge production, promote scientific and technological progress and innovation, and finally accelerate national economic growth. Patents provide the legal protection for an invention that is novel and non-obvious and application of discovery, concept, or a new idea that is useful. The legal protection from plagiarism of any creative work, scientific or business publications, movie script, computer software, music, and any information compiled in written form is provided by copyrights, which is automatically created once the ideas are fixed in a permanent medium. The rights to use logos, specific words, symbols, different features, or markings that indicate the source or origin of a service or product are provided by trademarks (Brown, 2003). Another method of gaining profit from an invention is keeping it secret rather than disclosing it—a "trade secret," e.g., Coca-Cola's formula.

One of the areas where innovators will encounter IP law is in employment contracts.

In most cases, Innovators are required to allocate all inventions made during their employment to their employer. In fact, in our knowledge-based, high-tech economy, the subject is difficult to avoid. IP and IPR influence almost everything innovators do. It is what gives institutions and innovators the incentive they need to innovate. The need to connect the dots for better decision-making resulted in the formation of intellectual property analytics (IPA), the data science of analysing the vast amount of IP information that has witnessed remarkable developments in this field over the years (Aristodemou & Tietze, 2018).

Figure 1 and Figure 2 illustrates an upward trend in the past decade in the number of patent applications in this particular field concentrating on the subject area like computer technology, semiconductors, pharmaceuticals and nanotechnology and fields of technology like chemistry and engineering, respectively.

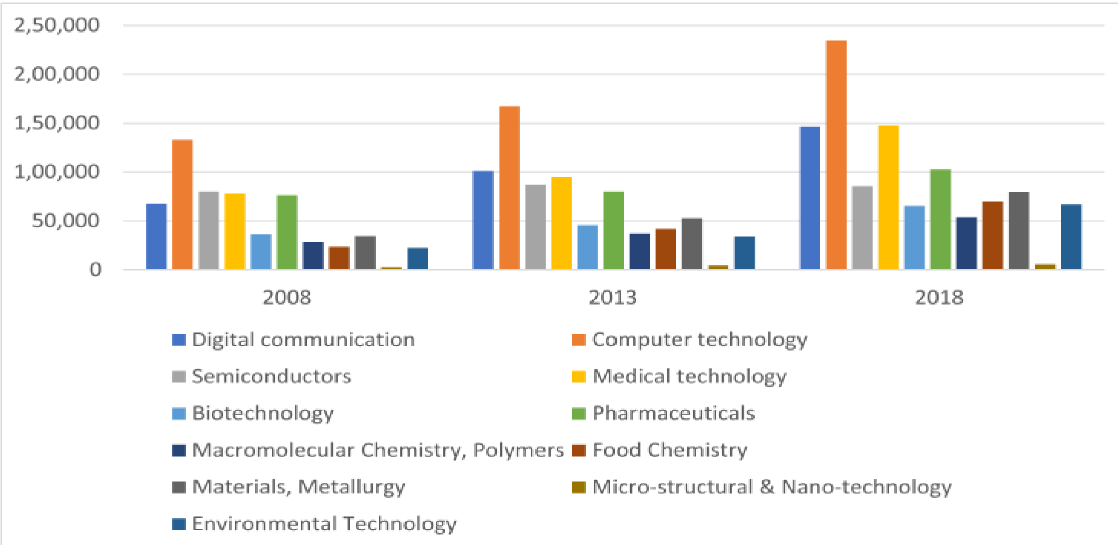

Figure 1: Published Patent Applications Worldwide by Subject area (WIPO, 2020), 2008, 2013 and 2018

Science and IPR: the two cultures

In 1959 C.P. Snow wrote a famous essay named "Two Cultures," in which he opposed the great cultural divide that separates two significant areas of human intellectual activity, "science" and "the arts." He argued that these two areas, which acts as the playground for the human intellect, should benefit society and players delving into both areas should build bridges to step-up human knowledge progress. The same spirit is required when we talk about Science and intellectual property rights, as Science is not a private endeavor. Despite being uncertain and controversial, the ownership of IP has been significant historically. Who has ownership rights in Science, under what circumstances, and how free are they to transfer the "owned" intellectual property to others?

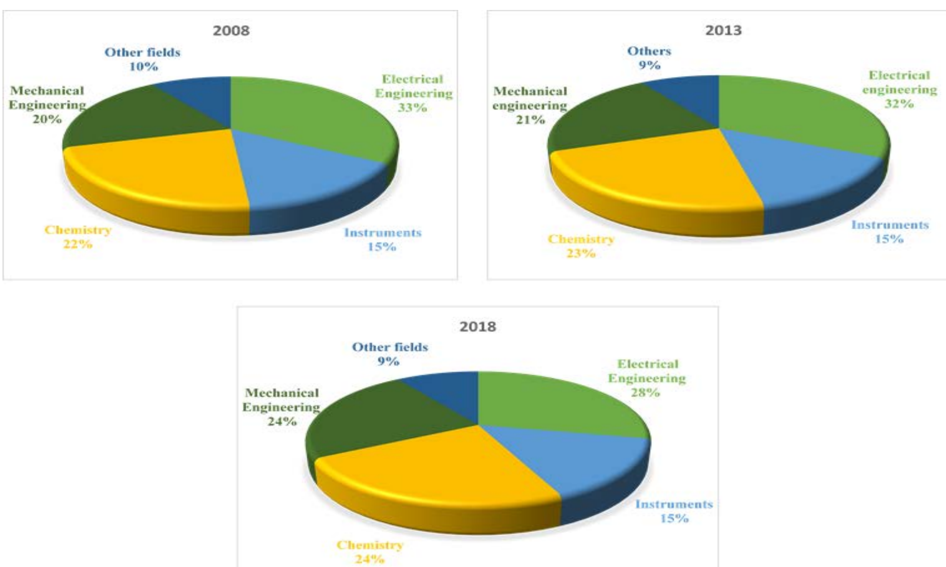

Figure 2: Share of total (%) Worldwide Published Patent Applications by field of Technology (WIPO ,2020), 2008, 2013 and 2018

The answer can be easily given by a scientist who is fully equipped with the required legal knowledge. Scientific ideas or discoveries that are not disclosed cannot be given intellectual property status, and the originator of such findings cannot claim them. Ownership of ideas is a representation of a static claim over a dynamic process of production. Innovators must publish their work for it to become their own. The only way an innovator can get surety of being credited with the originality is to give their work away by conveying it to the scientific community. The issue regarding the ownership of intellectual property causes anxiety in innovators and provokes a conflict between claimants, all of whom consider their rights valid. Many countries, along with India (Jajpura, Singh & Nayak, 2017), have shown exponential development by using the IP system to protect and promote their indigenous knowledge and creations, which eventually attracts foreign attention, contributes to the transfer of technology, and increases nations' wealth. Table 1 and Figure 3 represent the IPR filing activity of some leading countries.

Table 1: IPR filing activity of India in Comparison to few leading Countries in 2019 (WIPO , 2020)

Type of IP	Country	Applications filed
Patent	China	14,00,661
	USA	6,21,453
	Japan	3,07,969
	Republic of Korea	2,18,975
	European patent office	1,81,479
	Germany	67,434
	India	53,627 (RA: 19,454; NRA: 34,173) *
	Total application worldwide	32,24,200
Trademark	China	78,33,081
	USA	6,72,681
	Japan	5,46,244
	European union IP office	4,07,712
	France	3,11,634
	Russian federation	3,06,976
	India	3,67,764 (RA: 3,22,297; NRA: 45,467) *
	Total application worldwide	15,153,700
Industrial design	China	7,11,617
	European union IP office	1,13,319
	Republic of Korea	69,360
	Germany	44,097
	USA	49,848
	Japan	32,176
	India	13,723 (RA: 9,381; NRA: 4,342) *
	Total application worldwide	13,60,900
*RA: Resident Applicants and NRA: Non-Resident Applicants		

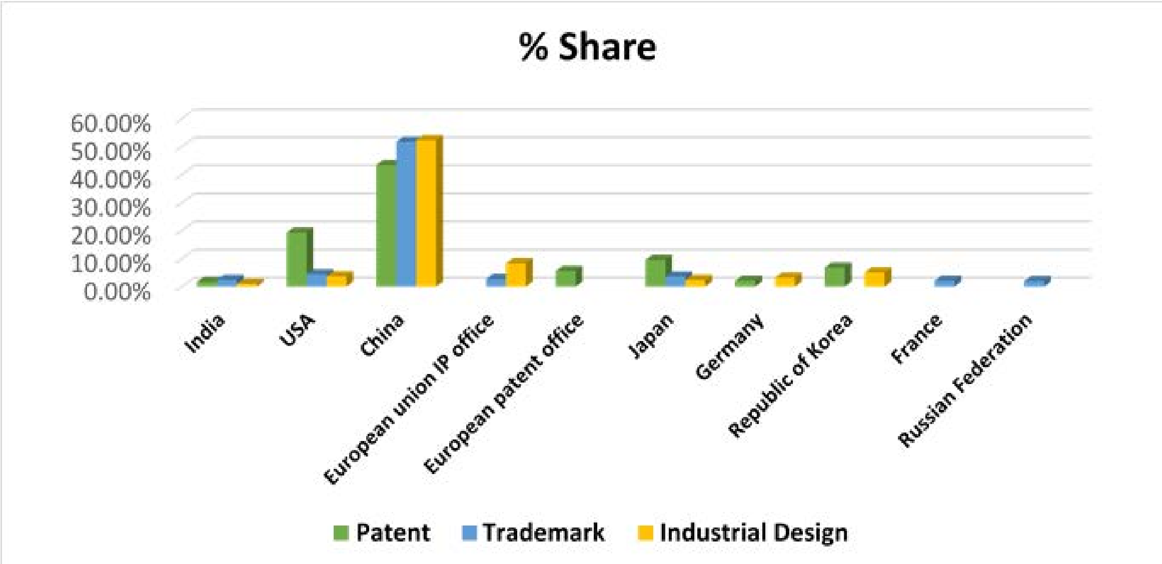

Figure 3: %Share IPR filing activity of India in Comparison to few leading Countries in 2019 (WIPO, 2020)

As far as the patents are concerned, the commodification of Science has produced a gold-rush system for them. Anything that might conceivably have used is now being patented, including the very stuff of life – a sequence of DNA – as well as applied lab techniques. The reasons for this gold-rush can be seen within the rapid progress of science and technology, primarily due to the significant shift from physics to biology in the post-Cold War era, which eventually directed the focus on areas like life sciences to come under the umbrella of intellectual property rights, and possibly even more decisive was the impact of the establishment of the World Trade Organization (WTO) in 1994, with the new General Agreement on Tariffs and Trade (GATT 1994) and also the International Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). For the protection of IPR, especially within the area of patents, TRIPS introduced mandatory international standards for the first time in history, and the opening of international markets was the result of GATT 1994. In particular, to all WTO members, patents must be available under the TRIPS agreement for inventions in every field of technology. After the establishment of WTO, the characterization of development was determined by the globalization of markets and the globalization of research and development (Andersen, 2012). Below are few points which can prove to be valuable ideas towards the objective of the potential interface between the scientific community and policymakers for contributing to an in-depth understanding of the relation between cause and impact of intellectual property rights:

- Increase of collaboration space between Science and IPR.
- Increase development-driven scientific research through more dynamic outreach across both sectors.
- Participation of scientific community in planning new laws regarding IP so that science-based solutions to IP problems can be considered from the beginning.
- Access to legal knowledge should be promoted by providing adequate information.

- The regulatory reform should be supported to create sustainable ndustry/ researchers' partnerships by the country's government communication regulators, resulting in enhancement of investment and growth.
- Scientific work should not be limited to conventional institutions like universities, government research centres, and corporate laboratories. Setting a science-development community interface will eventually increase the number of sites where knowledge will be created.

CONCLUSION

The scope of Science and technology is broad, and the importance of Intellectual Property Rights is increasing as we progress further. Science is profit. Moreover, profit often determines the direction of Science. The total commodification of Science, and its increasing domination by commercial and consumer interests, is also transforming Science from within, and the main concern in the past within the field of IPR was with the introduction of high-tech achievements. After entering the 21st century, market and private sector imperatives started driving the scientific and technological advances and determine what does and does not get funded, which eventually made the changes in Science much deeper. This marriage of Science and profit can be detected in the significant rise of intellectual property and its awareness among the developing nations as IPR becomes the tool to bring forth enormous wealth by strengthening their national innovation capacity. A significant challenge for many developing countries is to fight the new predatory nature of Science usually practiced by developed nations seeking to patent non-western genetic resources, which began with the neem tree. The solution to that lies in developing national scientific and technological infrastructure using the intellectual property (IP) system for the promotion and protection of indigenous knowledge, ancient learnings, and domestic creation for attracting foreign direct investments (FDI). In Science, conflicts over the ownership of IP question scientists' and researchers' awareness of intellectual property rights, and if lack of legal knowledge is the root cause, then in the anticipated future, these conflicts are nowhere going to stop. Conceptually, Science is changing because uncertainty and ignorance are now crucial elements of all scientific endeavors. Uncertainty occupies the center stage when the policy is involved, and therefore, there is a responsibility upon policymakers to create an environment where researchers and innovators are aware of their rights and can work without any hesitation. Furthermore, policymakers are responsible for making an environment for both the private and public sectors where there are proper incentives to grow that science and information base for humankind's benefit.

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Chapter 11

Innovations in Science Education with Special References to Chemical Sciences

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Innovations in Science Education with Special References to Chemical Sciences

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ABSTRACT

Innovation in science and innovation in science education are of two different subjects of discussion but they are interrelated. Innovation in science means to create or to develop or to generate knowledge in novel way by research in basically scientific field of study. But innovation of science education means to convey or to communicate the generated knowledge to the students or learners of different levels in such a manner so that their ultimate change of skills or behaviors may occurred in formal education system. But that needs innovative and judicious analysis of content to incorporate in curriculum, novel method of transaction with complete understanding of knowledge among the learners, and innovative method of evaluation to proper certification gauging of the learners' achievement level. Chemical science is a very important branch of natural science that have a huge list of complex contents, concepts and process to understand the nature and environment. Innovation in chemical science education is a biggest challenge to school teacher, College and university professors and even scientists who are engage to communicate the message to learners or target groups. Different innovative methods of transactions have already been generated by educationists beyond lecture methods according nature of contents. But using of low cost no cost TLM and hands-on experiments with available local resources may help to develop innovation in science education especially chemical science education. Author is trying to make little bit familiarity to discuss such some examples in this article keeping aside a big area of research in innovation of science education to investigate.

Keywords: *Science; Science Education; Innovation; Chemical Sciences; Chemical Science Education*

INTRODUCTION

Differences between science and science education

Generally, formal education system all over the world from KG to PG deals with concepts and contents of four disciplines viz. Language Science, Social Science, Natural Science and Mathematical Science. All disciplines are scientifically framed in such a way from known to unknown and simple to complex so that, a sequential progress of behavioral changes of a human being may framed for future society with a balanced personality. Therefore, all these taught areas of different disciplines are related to science or scientific method. But physics, chemistry, biology, geography, geology etc. are such those subjects which deals with nature and science of nature, for which we have to understand here science or science education means laws of natural science and science present in nature.

The basic characteristics of natural sciences deals with laws present in nature and environment must be experimentally verifiable for universal acceptance. Generally, Scientists, discoverers and inventors of natural science subjects try to generate concepts as process and contents, which are incorporated as curriculum of different levels. These are called subject matter of science. But these are not called as science education. Science and science education are not same at all. Science deals with only contents and concepts areas of a particular subjects whereas science education deals with justification of arranging concepts and contents in the curriculum and syllabus under the guidance of philosophical bases, psychological bases and sociological bases. Furthermore, science education deals with best choice mode of transaction of the concepts of curriculum to the learners according to the learners' level (Kalogiannakis, 2021).

Last but not least, that science education also encompasses the most suitable and acceptable method of evaluation for judging the learner's behavioral changes or skills developed after transaction the curriculum. It can generally be told that each kind of education differs from its name of subject in three ways by framing curriculum, choosing best teaching learning methods and optimal evaluation procedures. These will be cleared in mentioning the differences in environmental science and environmental education, similarly for chemical science and chemical science education (Ramadas, 2013).

Innovations in science education

Innovations in science education is clearly deals with teaching learning methodology in classroom situation. Teachers play the role to transact the message present in the text of a concepts in such a way that learners could get a vivid picture of that and change his or her behavior accordingly in future. Here, lies the innovations with improvisation of science education (Tytler, 2009).

Chemical sciences

Generally, Chemical science is called as chemistry. The subject chemistry deals with chemical aspects present in the nature and environment. As physics deals with physical aspect of nature or environment, biology deals biological aspects of nature and geology deals with geological aspect of nature, similarly chemistry deals with chemical aspect of nature or environment.

Chemical science education

In the modern world application of chemistry is started from the very beginning of life to an individual and even from morning to sleeping night for each and every one. Therefore, an individual may not be a learner of chemical science but essential knowledge of chemistry is always a weapon to live on the earth may help others let to live via medicine may be synthetic or herbal.

In this situation, teaching -learning of chemistry or chemical science is a useful tool from school education to higher education by which a deep-rooted impact on development of knowledge and life skill for each learner is possible. Here lies the role of chemistry teacher or professor by whom the complex ideas and concept will be imparted or transacted in classroom situation through some innovative or improvised way that seems to learner as a folk-story to pay full attention to learn. Achievement of learners may be evaluated by Chemistry teacher in such a way that learners can enjoy the learning as joyful game. This is what is called chemistry education. This will be discussed and illustrated with some examples.

REVIEW OF LITERATURE AND DISCUSSION

The formal education system for imparting knowledge generally follows classical lecture method with chalk and talk in the classroom situation all around the world for more than a century. The printed non-illustrated black and white textbook and monotonous teacher-centric lecture makes the education as a horror to students of every level specially in higher education. Neither the teaching is interactive nor it is interesting in any way as there is no novelty of teaching or innovative practices in the classroom teaching-learning process so that learners could feel free to ask questions or any inquisitive arise in their mind for creativity thinking (Sahin, 2020).

Innovative practices are those actions or activities engaged by man through which new inventions are produced into the society. Innovative practices can be seen in different areas of health and medical field, communication of messages, agriculture field, Industrial domain, Governance and administration, Education field etc. Here, the author will try to show some innovative practices in teaching learning of chemistry both in school education and higher education on some fundamental concepts. This present paper is being developed to examine innovative practices in chemical science education which is identified as a panacea for improving students' academic achievement in science subjects specially in chemical sciences. These write-up with explanation will examine innovative practices in science education in the areas of chemical science education curriculum, teaching and learning, improvisation in chemical science education with innovative evaluation procedures (Zidny, 2020).

Innovative practices of Teaching-Learning methods beyond Lecture method in science education are as follows.

1. Demonstration method
2. Lecture cum demonstration method
3. Heuristic method
4. Discovery method
5. Programme Learning Method
6. Project method
7. Laboratory method
8. Inductive method
9. Interactive participatory method
10. Method using low-cost or no-cost teaching aids
11. Method using ICT and multimedia
12. Field study method
13. Constructivist method
14. Deductive method
15. Problem solving method etc.

All these methods need Teacher's depth of knowledge and wisdom with a creative mind of innovation to search Teaching-Learning materials (TLM/LTM) or Teaching-Aids (TA) especially Low-cost or No-cost category available in his or her surroundings (Udu,2018).

As for example, the fundamental concepts in chemistry or chemical sciences for both school education and higher education system are air, water, soil, compounds, elements, atoms, molecules, atomic structure, subatomic particles- proton, neutron, electron, periodic table, chemical bonding, oxidation-reduction, acid-base, radioactivity, complex salt, stereochemistry and many more. To develop interest and motivation in chemistry among learners of school education from grade VI to grade XII, teacher must have to take innovative teaching-learning methods with use of improvised TLM and ICT. Even to develop abstract concepts among learners in Pre-Graduate and Post-Graduate courses professors should take the help of innovative teaching-learning methods in teaching of thermodynamics, kinetics, electrochemistry, organic reaction mechanism etc. By these approaches of teaching learning process learners will inspire themselves for creative thinking that helps much in research work in the respective area of research in future (Sjöström, 2018).

Now as an example, we take how demonstration method and lecture cum demonstration method with improvised teaching-learning materials of low-cost could help learners to understand gradual development of atomic structure from Dalton to Schrodinger model via Rutherford and Bohr concepts.

For Dalton: Demonstration with TLM used a small stone to dust via sand of different size.

For Rutherford: Few iron wires with different color balls as electrons and protons may arrange in concentric manner in a planner two-dimensional arrangement with particle character.

For Bohr: These Rutherford model in modified manner with cotton tape or wire to understand the level of energy as $mvr = nh/2\pi$, similarly for Sommerfeld also for principal and azimuthal quantum level of energy.

For Schrodinger: To understand electron charge cloud density white cotton could be used to make understand the presence different amount of negative charge of electrons around the nucleus.

In this way concept of orbit to orbital could be developed among learners very easily rather than chalk and talk method. Illustration may also be done more vividly using audio-visual and animation through computer, multimedia and ICT. But in all these process teachers are to be very careful that learners can also use to handle these TLM to understand the concept in deep-rooted manner. All these are innovative and improvised practices of teaching learning chemistry according to the availability of resources and temperament of students and teacher (Collins, 2021).

Second example: To understand of electrolysis of water and to produce hydrogen and oxygen and their quantitative amount and followed by identification be easily done by the process of hands-on experiment before the students with two waste blade and water with a little amount of common salt or lemon juice. This experimental demonstration with interactive participatory method through thought provoking questions will make a clear concept and learning by doing helps a retention of concepts also.

Similarly, just with a steel spoon of cost Rs.one or two, helps to understand the following concepts of natural science viz. metal-nonmetal, rusting, electroplating, conductor-nonconductor of electricity and heat, liver, concave and convex reflector of light etc. Teacher can utilize it as a stimulator in classroom transaction as innovative practices in science education.

In case evaluation of learner's understanding or achievement level teacher may take the help of such innovative methods to perform by the learners. Thus, make the learners without any fear to learn every scientific and technological development occurs till the date. But that needs teachers' or professors' orientation to innovative practices of teaching-learning in the classroom situation to transact natural science subjects. It is the basic motto of innovative science education.

CONCLUSION

At the end of discussion, it may be concluded by stating that innovation in science education is an essential part of education system of whole world that make natural science as student friendly subject to learn. Scientists, Teachers, Professors, Educationist and Science Communicators must always make a research mind that abstract thinking concepts of natural science subjects may taught in the classroom situation so that learners may motivate to take these subjects as no hard one. Innovation in science and innovation in science education must walk with a feeling of fraternity.

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Chapter 12

Systems Thinking in Chemistry Education

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Systems Thinking in Chemistry Education

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ABSTRACT

The article outlines the recent development in including systems thinking in chemistry education. Overcoming the limitations in reductionist approach in science education, by organizing programmes and courses at different levels, one can connect the knowledge in chemistry to social, economic and environmental systems. An attempt has been made to relate Richmond's seven systems thinking skills to address chemistry related application of the skill. A more refined systems thinking hierarchical model is devised to implement in reality overcoming the drawbacks of the former model. Finally, future directions of various projects aimed from school to professional training courses had been discussed.

Keywords: *Systems; Thinking; Reductionist; Chemistry; Reinforcing; Balancing*

INTRODUCTION

Systems thinking provide information of chemical reactions for a good understanding of how the knowledge of chemistry links socio-economic, technological and environmental aspects of the world. Systems thinking emphases on (i) the way a system's integral parts interconnect, (ii) how systems function over time, and (iii) how systems work within the framework of bigger systems. In contrast to traditional analysis, the systems thinking work by breaking the system down into their separate elements. It is applied in the study of health related, ecological, political, commercial, human resources and learning systems. Mary Kay Orgill has rightly described the systems thinking as a method for scrutinizing and addressing complex behaviors from an all-inclusive perspective (Orgill *et al.*, 2019).

REVIEW OF LITERATURE

Reductionist approach in science education

A complex system may be understood by breaking the system into simpler components and analyzing each part. The reductionist perspective on science education is explained by MacInnis (MacInnis, 1995). In a reductionist structure, knowledge is transferred by the teacher to the student. Information is made up of fundamental units of skill which are grouped. In this model, the content of units and the sequence of presentation are determined by the teacher.

Consequences of reductionist approach

Reductionist approach helps us in the following ways:

(i) increase our scientific knowledge

(ii) reduce complex problem into simpler components easily understandable

(iii) helped to develop new technologies to aid knowledge

Limitations of reductionist approach

As a saying goes, a full is often more than the summation of the fragments. A reductionist framework suggests, if only the parts of a whole are analyzed as discrete entities, we can get knowledge of the whole. In contrary, research indicates that we shall miss important interrelationships and interactions between the parts if we concentrate on parts as individual discipline (Anastas, 2019). In reductionist approach, students fail to

(i) generalize the idea learned into a broader perspective

(ii) connect new knowledge to previously learned information

(iii) apply learned skills in new contexts

(iv) cohere human influence with scientific knowledge

Components of systems thinking

Systems include microscopic and macroscopic entities. Each system has at least three features: (i) a purpose, (ii) components or parts to carry out a "purpose" optimally, (iii) interconnection between components, (iv) the direction in which the "parts" are organized.

System thinking is not a "replacement" to the reductionist approach, but a "complement" to it. It helps in educating the future citizens immensely. It uses tools, strategies and rational frameworks. Systems thinking are the tools and rational bases to aid our knowledge in intricate behaviors within and between systems. It helps in our ability to (i) envisage the interconnections between the system parts, (ii) examining the variation of behavior with time, (iii) scrutinizing how new situation emerges from the interactions between the parts of the systems.

Reinforcing and balancing process

A system behaves by the involvement of two processes: (i) reinforcing process and (ii) balancing process. A supporting process leads to an escalation in the number of system components. A balancing process checks the growth of reinforcing process. In absence of a balancing process, the system will collapse. So, it maintains equilibrium in a particular system.

Feedback system

System maintains its stability through feedback. Attention to the relevant feedback from students can be a solution to counter a problem, rather than wasting resources on a fruitless approach.

Systems thinking in chemistry education

Challenges like sustainability is a global problem now what mankind is facing. Through innovative researches, chemists help us to live a life what we live today. We need chemists to maximize our natural resources efficiently by minimizing hazards and pollution. Citizens on the other hand need to deploy judicious decisions and scientific based policies to interact with them. This is basically the essence of systems thinking approach in education of chemistry. Mahaffy and his co workers (Mahaffy *et al.*, 2019; Flynn *et al.*, 2019) uses gears and cogwheels as a pictorial image for the three nodes, to emphasize the interconnection of the nodes and to study the activity of each component of education has on others. They are briefed as follows:

(i) The Education Research and Theories Node describes the work process for learners, learning theories, cognitive aspect & social context of education,

(ii) The Chemistry Teaching and Learning Node includes challenges of educating chemistry and student learning outcome. It includes responsibility for a harmless and viable use of chemistry,

(iii) The Earth and Societal Systems node works in chemistry learning towards addressing social and ecological issues.

The 2017, the International Union of Pure & Applied Chemistry (IUPAC) launched a worldwide project to add systems thinking in the chemistry education (STICE). The aim is to aid the chemists and citizens to talk about the challenges our society and environment faces, enrolling introductory chemistry courses in upper secondary levels. This includes its use in green and sustainable chemistry. It outlines the following features (York & Orgill, 2020):

1. How we learn: Formulating a framework of STICE
2. Integrating green and sustainability chemistry ideas for post graduate level chemistry laboratories & classrooms
3. Evolving systems thinking assets for chemistry teachers and learners
4. Classifying the investigation needed to enhance system thinking approaches
5. Openings to apply chemistry related methods in other avenues of science & biology and also in meeting social and environmental needs Another key point is to educate fresh pupils about the basic units of sustainability. This term was introduced by Anastas and Zimmerman in 2016 (Anastas & Zimmerman, 2016). It elaborates many environmental issues that are derived by considering fundamental basic units; solutions that evolve from molecular levels.

The role of chemistry in attaining sustainability agendas in a number of ways is illustrated as follows:

(i) Growth of environmental green chemistry as a multi-disciplinary science

(ii) Formulation of green chemistry principles and practices

(iii) Presentation of life cycle assessment (LCA). It includes steps from purchase of raw materials to the reprocessing of unused products

(iv) The development by the International Organization for Chemical Sciences in Development (IOCD) of the conception of “one-world chemistry”.

A development of systems thinking in chemical education is the Haber – Bosch reaction. It is approached from a limited consideration of the reaction in the curriculum text to a more integrated approach including the behavior of important reactive species of nitrogen and their contribution in social – economic system. This had been elaborated by MacInnis (MacInnis, 1995) in their article.

Model 1: Seven systems of thinking skills by richmond to address chemistry related issues

Barry Richmond was the first experts to pioneer in the systems thinking field. The skills were originally employed in business and management, but can address global issues too, like hunger, poverty, famine, ozone depletion, etc. Here the thinking skills have been related with chemistry related applications (Table 1).

Table 1: Richmond's Seven Systems thinking Skills to address Chemistry related issues

Richmond's system thinking skill	Description	Chemistry related application of the skill
Dynamic Thinking	time dependence of system's behaviour	concentration of reactant changing as a function of time
System thinking as cause	external cause of system's activities overruling internal causes for self assembly	interaction between the external forces in the environment to cause self association (micelles)
Forest mode of thinking	inspecting the system performance as a whole over the parts of a system	not considering a "compound" only as a whole in a mixture of reaction: how the surrounding atmosphere is taking part in the reaction (solvent effect) is the essence
Operational thinking	how variables change a system's behavior and how they cause it	identifying rise in temperature accelerating reaction rate and the cause (Arrhenius Equation) behind it
Closed-loop thinking	two system variables affecting each other	concept of common ion effect in group analysis – higher concentration of an ion playing a determining role in the solubility of another salt
Quantitative thinking	compare the relative impacts and absolute impact of variables on a given system	Le Chaterlier's principle: direction in which the system's equilibrium shift (relative to forward & reverse rates) in response to an external perturbance
Scientific thinking	To correlate models and hypothesis in practical life	Quantum mechanical models of a particle in a box to mimic a butadiene system

Limitations

1. The skills are not experimentally derived
2. The skills are not meant to be functional in a science education

Model 2: STH Model - Systems thinking hierarchical model

This model addresses both the limitations of Richmond's model. It has a pyramidal structure. It was formulated by Assaraf and Orion (Assaraf & Orion, 2005). They developed eight systems of thinking skills. It was subdivided into three levels of system modules from bottom to the top of the pyramid (Assaraf & Orion, 2005): (a) Level I: analysis (b) Level II: synthesis (iii) Level III: implementation skills.

Content of the model

1. A hierarchy and sequence is to be maintained in the model.
2. To progress to a higher-level skill at the top of the pyramid, a necessary but not sufficient condition for a student is to have skill in the lower level.
3. Level I: identify the constituents and practices within a system
4. Level II:

(a) identify associations among components

(b) identify active associations within the system

(c) organize constituents and methods within a relationship structure

(d) understanding cyclic nature of systems

5. Level III:

(a) format generalizations

(b) understanding the scopes of the system which are not visible

(c) prediction

CONCLUSION AND DISCUSSION

Future directions for STICE projects

The STICE project team suggests not a wrapped unvarying approach to systems thinking in chemistry education. Rather they put more weightage on bringing together diverse perspectives and critical approaches to systems thinking that will, ultimately benefit the society (Pazicni & Flynn, 2019; Ho, 2019). The following measures are taken to address this issue:

1. Course level learning outcomes: connecting chemistry information to socio-economic and ecological systems at work.
2. Training in systems thinking for future teachers: instructing and evaluating the use of systems thinking tools with chemistry curriculum.
3. The three levels viz. analysis, synthesis and implementation of system components for a improved knowledge of the elemental basis of sustainability are visualized by the hierarchical model pyramid of systems thinking.
4. Trainers are to deal with system complexity and understanding of chemistry content and relations with earth, environment and society. In the STICE framework, the Education Research and Chemistry Teaching and Learning nodes aid in the process.
5. Learning outcomes to illustrate chemical compounds having both hazards and benefits, which are to be dealt together.
6. Ecological and green chemistry can strengthen students understanding on the elemental basis of sustainability.

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Chapter 13

The Role of Green Chemistry Education for Sustainable Development

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The Role of Green Chemistry Education for Sustainable Development

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ABSTRACT

The concept of 'Sustainability' has received great attention during the last three decades. On the other hand, Green Chemistry became a rapidly flourishing field of research in recent times. The aim of 'sustainable development' is to live and work in such a fashion that protects the three important fields- environmental, social and economic security, not only for the present society but also for the upcoming generations. In this era of globalization, to meet the challenges faced by human society related to issues and problems of environment and availabilities of resources, green chemistry is becoming the strength which is leading towards sustainable development. So, there is an urgent requirement of awareness about 'Green Chemistry and its principles' among the students of high schools, to colleges, to universities of all disciplines. Green chemistry syllabus should get more importance in the academic curriculum. It will ignite sustainable thinking among young minds. In this chapter, the various principle of Green Chemistry and its implication towards sustainable development have been discussed.

Keywords: *Environment; Sustainability; Chemical Education; Green Chemistry*

INTRODUCTION

Chemistry education possesses an important place within the realm of science education (Taber & Akpan, 2016). It has drawn a great attention of the academic researchers and scholars worldwide and there are specialist as well as popular journals for chemistry education (Taber, 2012). Chemistry education plays a crucial role to train young generation to be responsible future citizens, so that the upcoming generations can shape society in a sustainable fashion (Burmeister *et al.*, 2012). To meet the global concern for sustainable future of human civilization, the chemical educators around the globe are reforming the chemistry curricula to be greener and safer (MacKellar *et al.*, 2020). The future generation chemists should give more emphasis on using the environmentally benign materials and techniques (Hjeresen *et al.*, 2000). So, the chemical educators have developed various innovative lectures and laboratory experiments that teach essential chemistry lessons without using the toxic chemicals that were mostly used in the past (DeVore *et al.*, 2009). In this article, various features of Green Chemistry as a part of Chemical Education has been discussed. The main focus of this book chapter is to elaborate the role of Green Chemistry to achieve the goals of sustainable development.

REVIEW OF LITERATURE

1. Green chemistry as a tool for sustainable development

The rapid process of industrialization is responsible for a revolution in the growth of the world economy. The heavy industrialization process which eventually leads to stronger economy, made a comfortable life for normal human beings. However, the economic growth is closely related to environmental pollution. The heavy industries release huge amount of toxic waste which eventually pollute the environment. Among all the industries, the chemical industries are the biggest source of toxic and hazardous waste (Lomborg, 2001). A few years ago, it was assumed that only less than 1% of commercial substances in use were hazardous. Currently, it has been observed that a reasonably much higher than anticipated proportion of chemicals in use are toxic for human health as well as environment (Pohanish, 2003). Now, we should find out a way that meets the needs of the current generation without compromising the ability of future generations to meet their own needs. It should be achieved without causing a lot of environmental damage and wasting limited resources. This type of development is called 'sustainable development' or (SD). Sustainable development will be more and more critical as the population of the world increases. The environmental pollution due to the growth of industrial activities was identified as a major challenge since 1940s (Park, 2009). To address this problem related to environmental issues, the companies have adopted few measurements. The chemical industries have modified their position on conventional production and product, development habits through conferences, political agreements and advances in chemical research and ecological engineering. They are constantly adopting sustainable processes to reduce the environmental damage.

1.1 Definition of sustainability

In 1982, United Nations established the World Commission on Environment & Development (WCED) led by Gro Harlem Brundtland. This special commission is widely known as Brundtland Commission. Brundtland Commission published their report 'Our Common Future' in 1987, which got worldwide attention on Sustainable Development (Brundtland, 1987). According to Brundtland Commission, Sustainable Development (SD) is "the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brinkmann, 2016). There are three main pillars which plays the most important role in Sustainability: the economy, society, and the environment. Sometimes, these three fields are informally correlated with- profit, people and planet.

1.2 Green chemistry principles

As per the definition provided by P. T. Anastas and J. C. Warner "Green Chemistry is the utilization of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture and application of chemical products" (Anastas & Warner, 1998; Anastas, & Kirchhoff, 2002; Anastas, 2011). They have postulated twelve principle of Green Chemistry-

(i) waste should be prevented at the source, rather than, to treat or clean up waste after it is formed at the end of the process.

(ii) synthetic methods should be designed in such a fashion which will maximize the incorporation of all the starting materials used in the process into the final product.

(iii) wherever possible and practicable, synthetic methodologies should be devised to use and generate substances that possess little or no toxicity to human health and the environment.

(iv) chemical products should be designed in such a way that it should preserve efficacy of function while reducing the issues related with its toxicity.

(v) unnecessary use of auxiliary substances e.g. solvents, separation agents etc. should be avoided whenever possible.

(vi) energy requirements should be recognized for their environmental and economic impacts and should be minimized. Synthetic methods should be conducted at ambient temperature and pressure.

(vii) use of a renewable raw material or feedstock should be preferred rather than depleting feedstock, whenever technically and economically practicable.

(viii) various unnecessary derivatization techniques such as use of blocking group, protection/deprotection methodology, temporary modification of physical/chemical processes etc should be minimized or avoided in the reaction process whenever possible. This is because, extra steps in the reaction process needs additional reagents and thus generates waste.

(ix) if possible, use of catalytic reagents (as selective as possible) is always preferable than use of stoichiometric reagents in a reaction process.

(x) chemical products should be formulated in such a fashion so that at the end of their function they do not stay in the environment and degrade into innocuous products.

(xi) analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.

(xii) substances and the form of a substance used in a chemical process should be chosen so as to minimize the potential for chemical accidents, including releases, explosions, and fires.

These ‘twelve principle of green chemistry’ states an ideal chemical reaction process which maximizes the efficiency and minimizes the hazardous effects both on the human health as well as environment. Although, it is nearly impossible to develop a ‘perfectly green reaction’ but the negative impacts of chemical research and chemical industry can be reduced to a great extent by implementing the twelve principle of green chemistry. That is why, the concepts of Green Chemistry are well accepted by the chemists around the globe. Currently, green chemistry is playing a central role in modern research innovation, initiatives, cooperation, networks, education and university courses (Lancaster, 2002).

1.3 Role of green chemistry in sustainable development

Both in the academic and industrial sectors a continuous effort has been devoted to addressing the challenges related to sustainable development. In the recent years, green chemistry is becoming the strength leading towards sustainable development. Green chemistry is nothing but the practise of a set of twelve principles which suggests to lower or completely eliminate the use or generation of harmful substances in the formulations, synthesis and applications of chemical products. In other words, Green Chemistry directs to use environmentally benign reagents, catalysis, solvents, raw materials, reaction methods, products and efficient processes as shown in Figure 1 (Varma, Afonso & Crespo, 2005).

Figure-1: Some Aspects of Green Chemistry

Nowadays, Green Chemistry is present in all countries around the world playing a vital role with an aim for sustainable development.

1.4 Traditional synthetic route vs green synthetic route

Practicing the green chemistry rules in synthetic chemistry have made the process more sustainable in the viewpoint of environmental acceptability. Green chemistry has given emphasis in the modification of various steps in the traditional synthetic chemistry such as- (i) waste minimization at source itself, (ii) use of catalysts in place of reagents, (iii) using environmentally benign reagents, (iv) use of renewable feedstocks, (v) improved atom economy, (vi) use of solvent-free conditions or recyclable environmentally benign solvent systems (Kirchhoff, 2015).

1.5 Green chemistry experiments in undergraduate chemistry laboratory course

It is very important to learn and built a sustainable culture for the long run of human civilization. Sustainability is a way of thinking and the students should be encouraged to practice it. The traditional approaches should be revisited and replaced by green approaches. The students should understand and be aware of environmental contamination and chemical exposure. As it is well accepted that green chemistry is a very important tool for a sustainable future, so, incorporation of sustainable thinking in experimental design in undergraduate chemistry courses is very much required (Gross, 2013). We must educate students about green chemistry in a way that encourages application of their knowledge. Application of green chemistry techniques in chemistry laboratory experiments for the undergraduate students is very much desirable (Morra & Dicks, 2016). Here in, two alternative synthetic methodologies that can be practiced in the undergraduate chemistry laboratory have been discussed.

(A) Detection of special elements (N, S, Cl) in organic compounds -through fusion with zinc–sodium carbonate ($Zn:Na_2CO_3 = 2:3$) instead of metallic sodium.

In the undergraduate chemistry laboratory, the detection of special elements such as N, S, Cl has been carried out using Lassaigne Test in general. The same test can be performed using Zinc–Sodium Carbonate ($Zn:Na_2CO_3 = 2:3$) instead of using metallic sodium (Mann & Saunders, 1938). The use of Zinc–Sodium Carbonate mixture over metallic sodium has so many advantages in the context of Green Chemistry -

(i) extremely safe as there is no risk of explosion or getting caught fire when plunged into water (frequent occurrence with metallic sodium, especially if taken in excess).

(ii) no additional precaution is needed during its storage for a long period of time as it is chemically unaffected by aerial oxygen and moisture.

(iii) experiments can also be performed with the aqueous solution of organic compounds (impracticable with Metallic Sodium).

(B) Organic reactions in solid state: benzil-benzilic acid rearrangement

Another one experiment that can be introduced in the chemistry undergraduate laboratory to teach the students about the essence of Green Chemistry is Benzil-benzilic acid rearrangement in the solid phase condition (Figure-2).

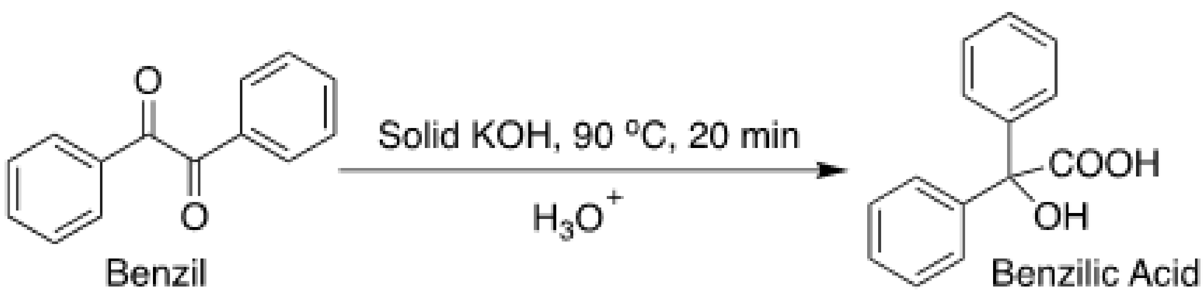

Figure-2: Benzil-benzilic Acid Rearrangement Reaction

Reaction methodology:

A mixture of finely powdered benzil and KOH was heated at 90°C temperature for 20 minutes. Then the reaction mixture was mixed with 3N HCl to furnish benzilic acid as crystalline solid (Toda *et al.*, 1990).

The green context in the proposed reaction methodology are-

(i) no need of any reaction solvent, so cost effective, less hazardous.

(ii) operational simplicity, very easy to perform

(iii) very fast reaction, so time saving

(iv) easy isolation of the desired product, so economical method

1.5 Future direction of green chemistry

The concept of green chemistry was evolved in 1991. After that, it has come a long way, growing from a small grassroots idea into a new approach to scientifically-based method for environmental protection and sustainable development strategy. At present, all over the world, governments and industries are jointly working with “green” chemists to transform the economy into a sustainable enterprise. It is anticipated that green chemistry may be the next social movement that will inspire the scientists, engineers and industrialists to work together to promote the development of this field for the betterment of society. The relevant development and judicious implementation of green chemistry principles will certainly contribute to the sustainable development of our society (Tundo & Griguol, 2018).

CONCLUSION

One of the main focuses of Chemistry Education is to promote the concept of Green Chemistry for socio-sustainable development. This article summarises the various measures of Green Chemistry towards sustainable development. Keeping in mind the environmental safety and public health, steps need to be taken by various industries and academic institutes to incorporate green chemistry for sustainable development. Traditional synthetic routes should be replaced and green synthetic route should be adopted whenever required and possible. Two modified green synthetic methodologies have been discussed as an alternative of traditional classroom methods to undergraduate chemistry laboratory.

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Chapter 14

'Virtual Lab' is a Promising Supporting Tool to Teach Next-Generation Science Aspirant

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ABSTRACT

The main objective of science education is to grow scientific temperament and attitude to the learners. Experiments, cultivate valuable observation and draw a conclusion is the prime feature of science education. Science pedagogy is unfeasible without the support of useful teaching aid. Now, the advancement of technology allows us to share the scientific content and materials at any instant. Web-based resources become an essential part of our education system. In this context, creates 'virtual lab' environments rich the e-learning process. 'Virtual lab' is to stimulate computer software that can provide a virtual image of the laboratory. In this virtual lab environment, an experiment has done virtually. Students get a pre-lab idea without handling the laboratory components. In this short manuscript, we explain the potentiality of 'virtual lab' tools to support our online teaching.

Keywords: *Science Education; Online Teaching Tools; Virtual Lab*

INTRODUCTION

In our country 'fundamental duties' of every citizen has been specified in the constitution under Article 51A (*Fundamental Duties*, 2020). Article 51A(h) has exclusively mentioned one fundamental duty, that encourages citizen “to develop the scientific temper, humanism and the spirit of inquiry and reform”. The scientific temperament means one can analysis the objects by scientific mind and eye. It is an attitude which provokes us to search the logic behind the fact. Only scientific environment and temperament of the society can motivate our young generation for innovative thinking. A country cannot move to fast forward without novel scientific thinking, appropriate technology and application-orient research. The interdisciplinary approach of science and technology can only bring the radical change our socio-economic status. Advancement and sharing of scientific knowledge can only add sustainable and comprehensive growth to the country (*Important to inculcate scientific temper in children*, 2019). Proper scientific teaching in pre-school to university level can build up a new-generation scientific community. Only the constructive scientific teaching approaches to the learner make the science enjoyable (Sharma & Shukla, 2002). Thus methods of science subject teaching are crucial (Rajendran, n.d.). Besides the traditional classroom teaching, ICT based teaching methodology can make science educations more approachable towards young learners.

Now a day, all are facing a global health crisis. The outbreak of COVID-19 paralyses our economic, social status and education systems (Gulati, 2020). Teachers are only communicating with their students via an online platform. Conducting practical experiments in the laboratory is quite impossible in this scenario. So students are not gaining lab-based training. Only stimulate software-based technology can bring the young learners an alternative path to get an idea about real laboratory experiences. Animated features, three-dimension view and high-resolution graphics make the virtual lab experiences popular among the school-goers (Jones, 2018).

In the 21st century, the style of science education methodology base on web resources. Online education portals Swayam- NPTEL etc. and various web-based educational platforms are quite popular among the students (Karra, 2020). UGC and MHRD continuously encourage teachers to switch over to online mood as far as possible. We must be incorporating a blended version to our education system. Our teaching pattern will run in both versions, online as well as offline mood. In this context, virtual labs are open up an alternative avenue to the teaching of the practical base subject. These alternatives tools support the e-learning process and help to understand basic science. In this chapter, we highlight the importance of laboratory training in science education and discuss its limitation. In this short manuscript, we are trying to give an overview of the virtual lab as a teaching education tools.

REVIEW OF LITERATURE

Scope and objective of science education

Science is knowledge based on experimental fact and observation. According to James B. Conant 'Science is interconnected series of concepts and conceptual schemes that have developed as a result of experimentation and observation and are fruitful of further experimentation and observation' (Demos, 1952). The correct way of scientific training can build up analytical power and a positive attitude among the learners.

Technology and science education methodology

A teacher can take help of various aids and methods to explain the science courses. Demonstrate the Science content we use a diagram, figure, chart, graph and laboratory-based experiments. Out of this many teaching aids, audio-visual mediums are a most accepted and powerful medium to teach scientific content (Lee & Reeves, 2007). In this mode, a student can understand the complex theory of science easily without memorizing. Teaching aids helps to explain science curriculum and use to get appropriate learning outcome from the learner.

Importance of laboratory in science

Science without a laboratory is impossible (Hofstein, & Lunetta, 1982). Science laboratory allows the students to relate the concept of scientific knowledge in the experimental conditions. A student can only realize the basic aspect of the scientific theory by conduct practical experiments in a science laboratory (Millar, 2004). Hands-on laboratory training is an important learning method in the undergraduate to post-graduate science teaching education. This laboratory training gives students exposure to reactions, materials, specimen and apparatus in a lab. Real experiences inspire students to pursue science subject. Lab-based skill prepares them for high-technology careers by improvement skills required by potential employers. Lab-based training is necessary for learning and improving science literacy. However, these laboratory facilities are still not extended to all our students for different reasons.

Challenges with traditional lab training

Limited or no access to physical laboratories

In this pandemic situation, since we follow 'social distancing' means students and employees have limited access to attend the lab at a time. In the 'lockdown' condition most of the educational institutes are closed, access to the laboratories is impossible. So students face of lack of practical training. Although in the virtual learning process, our students grasp knowledge about scientific theories.

Risk of accidents

All chemical laboratories are consisting of potential consumable or non-consumable hazardous chemicals. Experimenting with these harmful substances may be dangerous to the young inexperienced learner.

Expensive lab equipment

In our country school and undergraduate level colleges have limited fund. Inadequate numbers of machines, outdated equipment, lack of reagents and apparatus are common problems in our lab. Most educational institutes have not provided modern advance instruments or equipment to young learners for their experiments. Usually, students conduct experiments in practical class are in the group. It is due to lack of a sufficient number of equipment, chemicals and limited time period. Therefore, their skill development and learning experience are half-hearted.

Overcrowded labs

A limited number of apparatus, equipment and materials are available in the school and college level laboratory. So there is a rare chance and minimum time for the students to conduct experiments solely.

Lack of bridge between theory and practical study

Our science curriculum, in all levels, has so many theories and concept of science. However, it is impossible to demonstrate the microscopic and subatomic level reaction in the lab. So, sometimes young learner lost their motivation. Only software-based 'virtual laboratory' system can tackle the above challenges successfully.

What is a virtual lab?

Virtual labs (Virtual Labs, India, 11 February 2021) are on-screen simulated learning atmosphere that permits pupils to absolute laboratory experiments online mode and examine concepts and theories without stepping into a science lab. A virtual laboratory helps to get test ideas and observe results to perform a series of experiments. Students can try out lab techniques for the first time and become more familiar with advanced lab equipment that might otherwise be inaccessible. Through animations, students can explore life science at a molecular level and look inside the machines they are operating. Virtual lab software creates opportunities for alternative access to science education (The Complete Guide to Virtual Labs, n.d.).

Benefits of virtual labs

In this pandemic situation, the only virtual lab can provide partial lab experiences. This remote-access to labs would cater to the school levels, undergraduate and as well as post-graduate-level students. Science teacher can train the young learners' to learn and test their skills, before entering a real lab. They can demonstrate the experiments and explain the theoretical concepts step by steps behind the experiments.

To set up a science lab needs a lump sum amount of investment and space. Every year institutes allot a budget to purchase several instruments, equipment, biological specimens, glassware and chemicals. Installation of virtual lab-based software or programme package is also costly. Arrangement of several computers and high-speed internet facility set up is expensive. But, in comparison, it has minimized the initial establishment and recurring cost. Labster and other specific software company design a tool that provided virtual lab experiences. The institute has been drastically reduced expenses on equipment and lab-based expenditure through the virtual lab.

In a virtual laboratory, learners can attempt all kinds of experiments without the risk of damaging equipment or injuring themselves. In this lab experiments, they have no chance to expose themselves in front of hazardous chemicals. A simulated lab can guarantee safety to our learners. On the other hand, it can produce 'zero chemical waste.'

In the virtual lab, students can do repeat their experiments to get the desire results. They can set the different experimental conditions and compare the effective methods. They have got the freedom to practise as many times at their own space and time. They can visit around in a virtual lab, messing up, making faults, and learning from those faults.

A virtual, interactive lab session gives students ample facility to get the pre-lab experiences. It will boost our learners' confidence. Virtual lab training is safer method indeed. It does not allow students to expose with hazardous substances.

Most of the cases we find scientific theories are too abstract and very difficult to apply in real-life. For example, students are finding it difficult to understand the sub-microscopic levels in chemistry. Due to the ethical reason test or dissect parts of animals in the biology lab banned nowadays. So, students rarely get the chance to learn about these experiments. So that's teachers wanted to use simulations. An educational instructor pointed out that 'Labster allows a dynamic visualisation of chemical reactions so that students can practice and better understand these concepts, and consequently enjoy the classes more.' Even in the virtual world, they can create a crossbreed between two unknown species. It will help students to get an idea to conduct experiments by arousing their curiosity.

Comparison between real lab and virtual lab system

Virtual training doesn't necessarily fulfil the importance of conventional classroom teaching. It may consider as supporting learning system (Importance of Hands-on

Laboratory Science, n.d.). In programme based virtual laboratories, learners have the do experiment and practice as many times as they want, but it depends on the programme package. Virtual Labs experiences with additional web-resources, video-lectures, and self-evaluation can concrete the learning procedure. Virtual labs are open up the possibility to share the idea of laborious experiments, equipment and resources virtually. Computer interface with specific stimulation software can make a smooth and effective e-learning process. However, exact scientific knowledge can only earn and expand to experiments in the laboratory.

CONCLUSION

Nowadays, science teaching is not only confined in the classroom. E-learning becomes part of our education system. Different web-based technology and resources can complete the learning process. Teachers and students can continuously upgrade themselves to follow web-based information. The digital platform adds flexibility to the education system in terms of time, cost and space. This 'virtual lab' teaching aid can help students as a teacher to explain complex theoretical concepts. Computer simulations that mimic laboratory surroundings are to be a useful add-on to student hands-on activities, but not a substitute for them. However, technology-based pedagogy is effective when we provide a computer with a high-speed internet facility to all the students. Virtual labs are like to flight simulators that practise future pilots for flying. New features and more student-friendly interface make the virtual lab essential tools for the next-generation training shortly.

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Chapter 15

Science Education: Nurturing an Interest and Sparking a Desire to Learn More

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ABSTRACT

Every education should have a practical aspect to make life better, otherwise it is of no use or meaningless. The knowledge which prisoned itself in the pages of the theoretical books are useless. Science education is no exception in this regard as science and everyday life cannot and should not be separated. Education is not merely the learning of facts but the training of the mind to think. Thus, the objective of teachers is to prepare the students to ask the right questions. With the help of modern technologies, the science education now a days frees itself from conventional mode of teaching and making the learning process more attractive and interactive.

Keywords: *Science Education; Activity; Teaching Tools; Virtual Lab; Flipped Classroom*

INTRODUCTION

After fulfilling the basic needs of life i.e., food, cloth and shelter one turns to education – another tool that makes life easier. We have come across the much-heard line *'Education for all'* for quite a long time. Now a days it modified as ***'Science education for all'*** (DES, 2017).

Science as we all know is a fearful subject to most of the students as conventional method of teaching science does not attract them at all (Regan & DeWitt, 2015). In order to solve the problem, a whole new approach of teaching and learning science has been developed taking on account the students' ability, their talent, hobbies, interest and cultural backgrounds. The aim is to develop the scientific concepts by not just remembering the theory but understanding the practical aspects as well (Wu *et al*., 2018).

By breaking the conventional chalk and talk method, various other methods of learning, such as science project, drama, dance, science exhibition etc. are introduced. So that the students can be active learners rather that the passive observers (Falk & Storksdieck, 2005; Qutub, 1972).

Equal access to science education is a basic human right that belong to all. We cannot divide the society in two parts i.e., science literate and science illiterate. Thus, we should develop the right methods of teaching, learning and assessing science. The motto is to bring science lessons to life with real world application (National Research Council, 1997).

REVIEW OF LITERATURE

Different approaches

In this era of post COVID-19, when conventional mode of education has been stopped for so long time; science comes as a rescuer to help spread the education in distant remote areas. With the help of technology, a whole new approach is come forward to make science education more versatile, acceptable and reasonably interesting (Gomes & McCauley, 2021).

Let us discuss the methods one by one:

1. Hands on learning

Activity based learning is perhaps the best method as students are learning things by doing it (Sevli *et al.* 2013; Prins *et al.*, 2016). In this method, students are actively engaged to solve a problem, which encompasses the proper blending of their theoretical knowledges with practical experiences and applications. They can learn from their mistakes and thus clear the concept. By promoting the group activities, conceptual framework and problem-solving skills of students are also developed (Figure 1).

Figure 1. Learning Science by Doing Science

2. Audio-visual method

This includes story telling, role play, games, drawings, diagrams and pictures to assist theory and setting up examples to show its application side.

Laboratory procedure can be better taught through pictures and words approach.

3. Instructional conversation

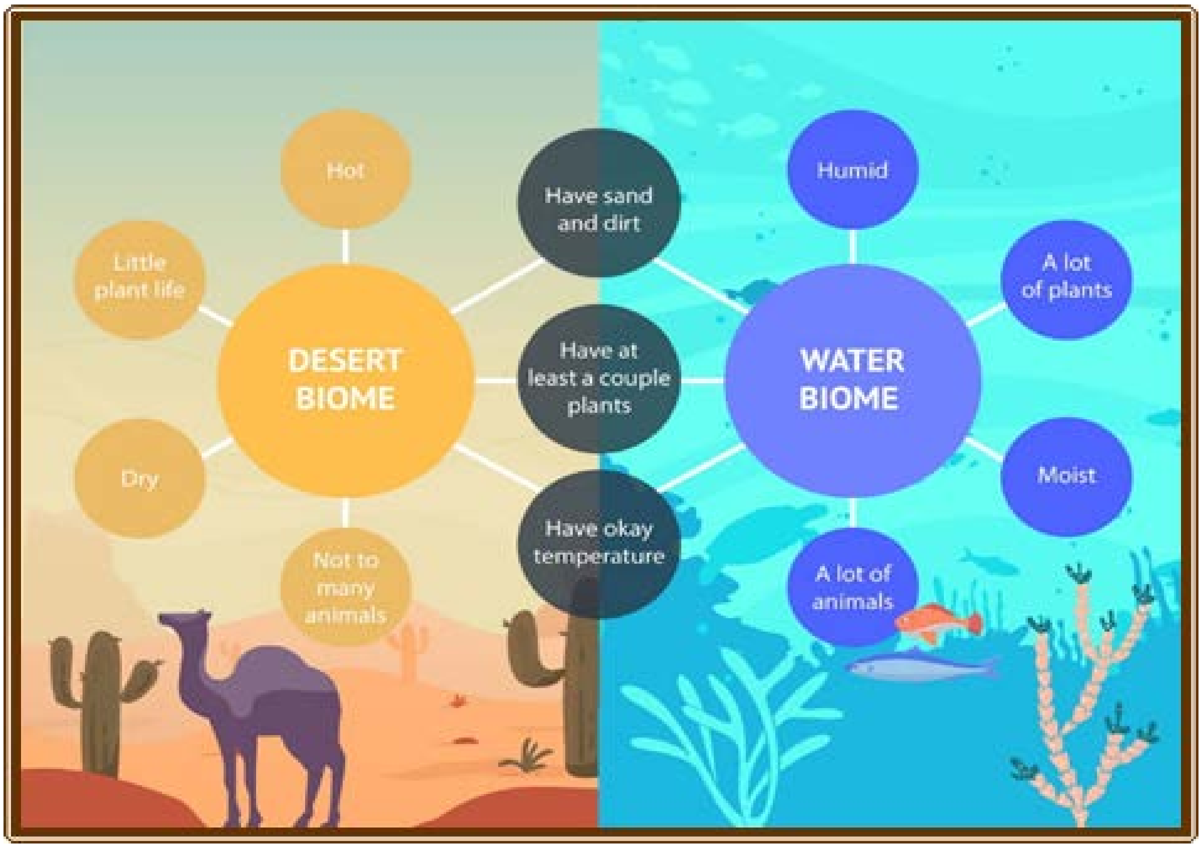
This is an interactive teaching – learning method by raising questions, discussion in between lecture help the learners to promote a better understanding of the subject (Many, 2002).

4. Science text cards

Statements related to science concepts are written on index cards based on the given format. It could be true/false, agree/disagree, matching pairs, classifications, sequencing and more.

5. Graphic organiser

It contains a central point from which different branches are formed. Arrows are used to point the direction or sequence of a process (Figure 2).



[Source: http://www.scoop.it/topic/into-the-driver-s-seat]

Figure 2. An idea of Graphic Organiser

6. Word part

This method helps to educate the basics of science to elementary students while introducing new scientific terms, they can reinforce the structure of words.

eg., Photosynthesis – photo (means light), synth (means to make), isis (means process); Hydrolysis - hydro (means water), lysis (means to break or cleave).

7. Using social media

Now a day's various apps are available to learn, share different documents which make the science classroom more interesting and engaging (Tal & Dierking, 2014).

8. Virtual science laboratory

It is an approach of learning the science practical beyond the classroom (Figure 3).

Figure 3. Virtual Lab

Detailed diagrams, illustrations or close-up pictures allow students to virtually get inside a plant or animal part without actually doing it. Imagine, doing a biological dissection without slaughter the animals or performing a chemical reaction without the possibility of hazards of burning hands, engulfing bad fume, smelling of poisonous odour or breaking the apparatus. Virtual lab can make this imagination possible. This approach almost gives hands on experience of learning the subject without much expense or hassle (Olympiou & Zacharia, 2011). Students also enjoy this risk-free learning method.

For those students who live in a distant, remote areas virtual lab comes as a blessing. They can get the essence of scientific experiments without the hassle of costly lab set ups with all it's equipment. It can save a lot of time and money.

Moreover, students can exchange their views and share their experiences more easily and conveniently, which ultimately makes the science education more interesting and effective.

9. Word wall

Science word wall in classrooms stimulate the interest of students in the subject. By preparing a bulletin board in the classroom with four columns using the Word Knowledge Continuum Cards, helps them better understand about a particular word with multiple meanings (Figure 4).

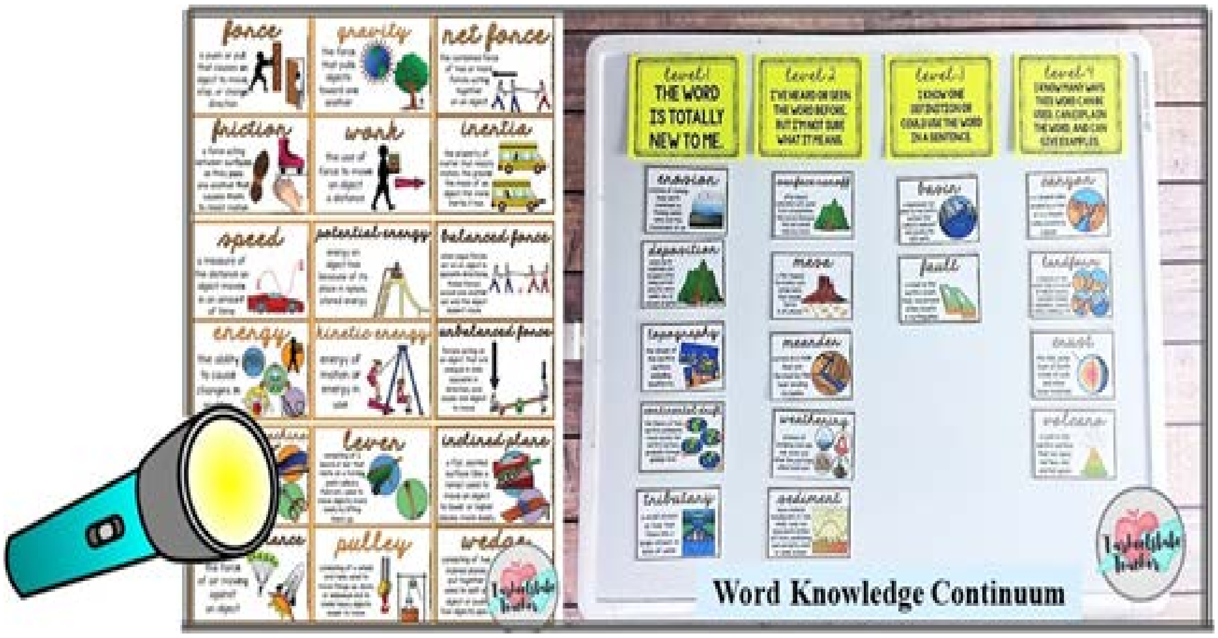


Figure 4. Word Wall

10. Crossover learning

Field trips, visit science fairs and science museums, participating scientific workshops and seminars etc. give opportunity to students to learn in multiple settings. These diverse learning events help them to explore the topic in a deeper level of understanding.

11. Argue with science

This is a method by raising a question which means learning through argumentation (Taylor *et al.*, 2008). It gives students the opportunity to widen their thinking, to contrasting ideas which in turn deepen their understanding. In this way scientific observations can be re-state or remarks in a more scientific language.

12. Computational thinking

It means breaking large problems into small parts and patterns and recognise it to the one's that has been already solved successfully in the past. This method improves thinking and problem-solving skills of the students (Scalise, 2012).

13. Science museum, science project, science fair, Science quiz, science movies and games for kids, science exhibition and Field trips

These all methods can be used to break the monotony of classroom lecture and making the science education more attractive and enhance the creative minds of the students for a better understanding of the subject (Ash *et al.*, 2012).

To organise quiz session among students make them inquisitive. Eventually they took more interest in the subject and thus enhance the learning process.

14. Using different tools

Multimedia approach enables educator to convey vast information using advanced devices and techniques to provide a meaningful learning experience by involving a wide range of activities (Kim *et al.*, 2007). Video clippings, use of graphics (Figure 5), animations and power point presentations also make the teaching more

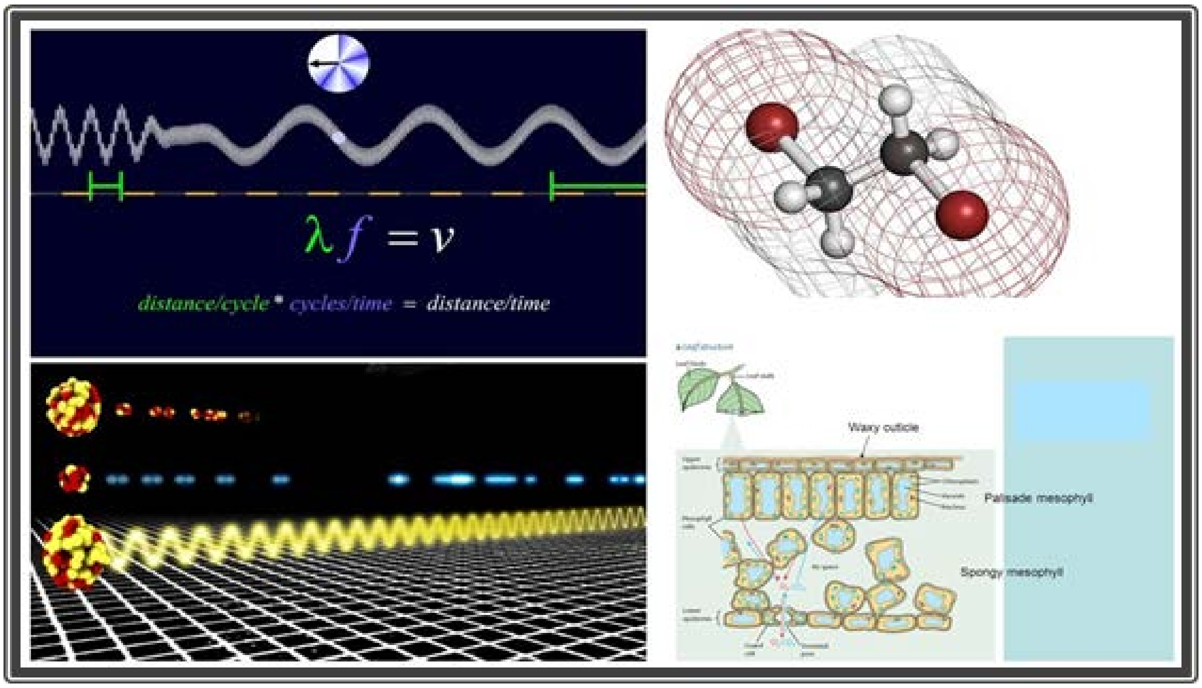


Figure 5. Graphics related to Science Education

attractive and interactive (Chazan & Herbst, 2012). To enhance the active participation of students during lecture session, different polling tools e.g., Plickers, Quizizz or Kahoot are incorporated.

15. Research books, magazines and journals

By the help of these resources' students are asked to do a project /research work on the topic studied in class rather than just follow the textbooks and lecture notes. In this way they will get extended information of their syllabus.

16. Documented problem solving

This method enhances the reasoning power of a student by promoting their thought process while solving a problem.

17. Science club, scientific workshop and symposium

It makes students more enthusiastic to share and discuss new happenings in the World of Science and getting innovative ideas.

18. Flipped classroom

This is a two-stage method; first of all, students are asked to learn something by virtual tutorials and in next step they have to apply this knowledge to do the tasks or some challenging activities in the classroom (Figure 6).

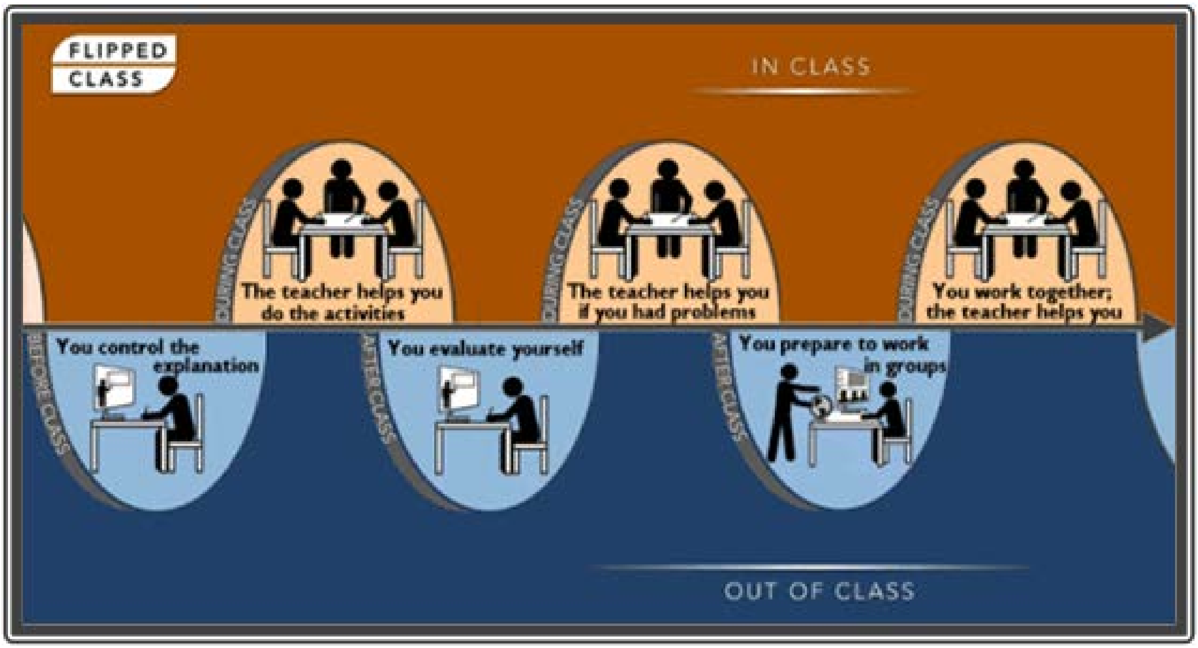


Figure 6. Flipped Classroom

The flipped learning method can save more class time for other activities like hands on labs, other simulation or guided practice (Altemueller & Lindquist, 2017).

19. Build your model

This method challenges the creativity of students (Figure 7). How well one

Figure 7. Different Science Models

understands the subject is reflecting on the model making by them. Therefore, building a model means blending the knowledge and imaginative power of a student.

This is the right approach to find the scientist in them.

CONCLUSION

The new era teachers and science enthusiasts have come up with many innovative teaching methods in science. The objective is to bridge the gap in between the privileged students and the students who lack the basic amenities.

To do so first of all we have to understand student sensitivities and differences and also keep in mind students learning style. Students engagement and understanding of materials is given more emphasis in today's education over spoon-feeding the facts; that means active involvement of students in their own learning. Promoting group discussion and group activities help the students to work as a team. It also helps students to develop problem solving skills and better concept.

Now, we live in a scientific world, where the varied, interesting and enjoyable advanced teaching strategies are helping students to discover and explore science every day.

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Chapter 16

ICT as a Powerful Tool in Education - An Overview

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ICT as a Powerful Tool in Education - An Overview

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ABSTRACT

In the digital era of the 21st century, Information and communication technology or ICT has touched all aspects of human life. The present times also witness the increased application of telecommunications in the field of education. Different ICT tools like desktop laptop tablet projectors, pen drives and smart boards have already been in use in the last few years for exchanging information and knowledge. Recently, smart phones have also evolved as important media especially in the online teaching-learning-evaluation process. Internet and interactive multimedia have removed the boundaries between nations with respect to education teachers are able to present their knowledge in an interesting and informative manner to the students with the help of ICT enabled tools curriculum needs to be integrated with technology as ICT forms an important focus for future education. This overview attempts to discuss some of the important aspects of the use of ICT in education.

Keywords: *ICT; Tool; Education*

INTRODUCTION

In the past few years, ICT has made its entry into different sectors of human life and education is no exception. Presently, it has become an inevitable part of the teaching-learning process. ICT stands for the collection of technologies that provide information through telecommunication. It has the potential to expand the sphere of education.

The traditional teaching pedagogy includes the chalk and duster method, face to face classroom interactions and predominant use of books and printed resources. With the passage of time and development of technology, these are getting replaced by online communications and resources. Both learners and teachers can interact simultaneously through teleconferencing classrooms. Studies have mentioned that ICT, when used effectively, can upgrade the literacy and numeracy of the students (Suryani, 2010). Children can be motivated to learn writing skill by using word softwares.

ICT has made information and knowledge easily accessible. With its help, education can be obtained anytime anywhere. Online study materials can be accessed anytime of the day and any day of the week. Multimedia resources include audio and video clips. The learning program which uses information networks, that is, e-learning, is gaining popularity day by day by generating interest among the students. Web based learning is a part of e learning. It refers to learning using an internet browser such as the internet explorer (Tinio, 2002). It promotes active and independent learning and its benefits are evident from the basic primary to higher education (Ratheeswari, 2018; Dubey, 2016).

This research aims to gain insight into the relationship between smart phones and students' attention in classrooms. This chapter further discusses the research method, the sampling method and the data analysis procedure.

REVIEW OF LITERATURE

ICT practices in education

E-learning- Also known as online learning, e-learning uses an information network which comprises an internet connection, an intranet LAN or extranet VAN. It is very much helpful in interdisciplinary research.

E-Modules- Short learning modules may be prepared by using word processor and stored into digital versions. They may include learning resources like video clips or direct instructions also.

Digital classrooms- Application-based virtual classrooms enable sharing of study materials between teachers and students. Online assignments and quizzes are also possible.

Messaging applications- Some messaging applications make it possible to exchange text pictures word files Excel files audio clips and even short video clips between Android devices.

Audio conferencing- Live telephonic conversations or exchange of voice messages can help in exchanging information.

Video conferencing- Various video conferencing softwares have become popular as they allow sharing of voice, graphics and moving real time images. This technology uses either a satellite link or television network (broadcast/ cable).

Web based conferencing- By this technology text graphic audio and visual media can be transmitted from one to another device both synchronously or asynchronously via the internet.

Open and distance learning- ICT plays a vital role in the delivery strategies of open and distance learning (ODL). It allows large scale participation and greater interaction. Due to the heterogeneous requirements in open distance learning it is very difficult to handle it with traditional systems of learning.

Essential conditions for ICT usage

To properly harness the power of ICT, some conditions are necessary to be fulfilled. Availability of digital devices with proper operating systems is a prerequisite to use ICT. Most of the IT practices also need good internet connectivity. Informative, meaningful and culturally responsive digital content must be prepared and be available in the website for teaching purposes. Teachers should also engage themselves in preparing good quality study material. They should learn new skills to utilise the digital tools responsibly for the benefit of the students.

DISCUSSION

ICT is being widely used in education such as nursing training (Webb *et al.*,2017) and allied health education (Liao & Liu, 2020). There is no doubt that ICT has improved the quality of education in many ways. However there are many issues and challenges which remained to be addressed. Well designed teacher training programs are essential in today's scenario (Pearson, 2003) so as to enable teachers to use ICT effectively for teaching Collis & Jung, 2004. Moreover, measures should be taken to ensure security issues and availability, authenticity and confidentiality of the contents presented for education.

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Chapter 17

Participatory Learning Method as an Effective Tool of Learning For Students: A Case Study

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Participatory Learning Method as an Effective Tool of Learning For Students: A Case Study

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ABSTRACT

Participatory learning is an effective tool for students in providing knowledge from field experiences. Simplified procedures are for our students in the year 2019. For that purpose we choose three villages from Sundarbans as the Sundarbans is one of the largest mangrove forests in the world and has been declared as National Park, World Heritage Site and Biosphere Reserve. The study was conducted to understand the agricultural practices of the rural people, livelihood pattern related to estuarine river and mangrove forest. People are engaged with agriculture round the year. But there are problems as per villagers' perspective that is salinity, flood and cyclone. Fishery also plays a significant role in socio- economic life in Sundarbans. Therefore, a comprehensive time-tested model of research and development with active participation of local people is needed in Sundarbans.

Keywords: *Participatory Learning; Livelihood Pattern; Mangrove; Estuarine River*

INTRODUCTION

The Participatory learning exercise is helpful for the students in providing knowledge from field experiences than class room learning and change their behavior and attitudes. It is an alternative mode of information gathering with an emphasis on qualitative rather than quantitative aspect (Reddy, 1999). It has been used in various sectors like natural resource management (soil and water conservation, forestry, fisheries, wild life), agriculture, health and nutrition etc. So, the students are prepared for work in those sectors.

Sundarbans is one of the largest mangrove forests in the world. It has been declared as National Park (1984), World Heritage Site (1985) and Biosphere Reserve (1989). However, research work in such a region has been mainly restricted to specific sociological, archaeological, anthropological, geographical, environmental and ecological aspects. Hence, interaction among ' man- agriculture- livestock- natural resources' in Sundarbans is a virgin field of research and development.

The current study embodies PRA exercise conducted in three villages of Indian Sundarbans with the students of B.Sc. (G) of our college to inquire about agricultural practices, livelihood pattern related to estuarine river and mangrove forest in the villages of Sundarbans and identifying the problems of villagers to prepare an action plan for agricultural development of those villages.

METHODS

1. Site selection for participatory learning:

For the purpose of collecting data very few places were chosen on Sundarbans. Three villages were selected from three blocks (out of 19 blocks) i.e. Amrabati village in Fraserganj GP (Block Namkhana) dated 16.7.2019,Durgagobindopur village of Patharpratima GP (Block Patharpratima) dated 02.7.2019 and Dayapur village from Satgelia GP (Block Gosaba) on 13.7.2019 of South 24 Parganas districts , West Bengal, India.

Table 1: Salient feature of three Blocks of South 24 Parganas

Feature	Patharpratima	Namkhana	Gosaba
Area	484.47 km^2	370.61 km^2	296.73 km^2
Population	331,823,	182,830	246,598
Male	169,422	93,351	125,901
Female	162,401	89,479	120,688
Schedule cast	76,163	47,260	154,484
Schedule Tribe	2,640	741	23,343
Density of Population (per sq. meter)	680	490	830
Total no. of Gram Panchayat	15	7	14
Total no. of Mouza	92	39	51

(Source: Census of India, 2011)

1. Tools and processes used during the activity:

I) Meeting with the Panchayet Pradhans: At the beginning, a meeting with Pradhan was conducted in the Gram Panchayet office of different villages to aggregate village demography and permission for entering in the villages.

Table 2: Village Demography collected from Gram Panchayet

Name of village With Block	Total no of Family	Total population			Total SC Population			Total ST Population		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
Durgagobindopur (Patharpratima)	**862**	2,278	2,048	**4,326**	125	118	**243**	0	0	0
Amarabati (Namkhana)	**1478**	3,432	3,243	**6,675**	2045	1,914	**3,959**	5	9	14
Bijoybati (Namkhana)	**1054**	2514	2377	**4891**	1,129	1,037	**2,166**	18	25	43
Debnibas (Namkhana)	**634**	1,412	1,299	**2,711**	271	242	**513**	0	0	0
Lakshmipur Abad (Namkhana)	**282**	599	577	**1,176**	342	347	**689**	3	3	6
Dayapur (Gosaba)	**1,215**	2,570	2,402	**4,972**	2,121	1,970	**4,091**	365	358	**723**

(Source: Census of India, 2011)

ii) Transect walk- this involves a systematic walk through the village along with local people (Das & Tripathy, 2012). Various aspects of the study were discussed with them.

Table 3: Transect Walk- Land Features

Village name	Land type	Land use	Soil type	Vegetation	Major Problems
Dayapur, GP-Satgelia, Block - Gosaba	Low land	Paddy - Fallow Paddy - pulses	Clayey	Mangrove vegetation like Bain,Keora, Geoa	salinity, flood, cyclone,lack of fresh water supply for irrigation
Amarabati, GP-Frasergaunj, Block-Namkhana	Flat	Paddy-Paddy Paddy – vegetable	Silty	Mangrove vegetation like Bain,Geoa etc.	Water logging in agricultural land, Proper agricultural and fishery training to the Youth of local communities.
Durga Gobindopur, GP-Pathar Pratima, Block- Pathar Pratima	Low Land	Paddy-Pulses Paddy – oil seeds	Clayey	Mangrove vegetation Like Bain,Geoa, Kankra etc.	salinity, flood, cyclone,lack of fresh water supply for irrigation, Water logging in agricultural land etc.

iii) Mapping exercise: Mapping can be various types like social map which depicts habitation pattern, infrastructure, supply and services; resource map which focuses on natural resources; census map which highlights information on individual households; etc (Somesh, 2002; Mukherjee, 2002). A map of Dayapur village drawn by the villagers, depicting natural resources of the village.

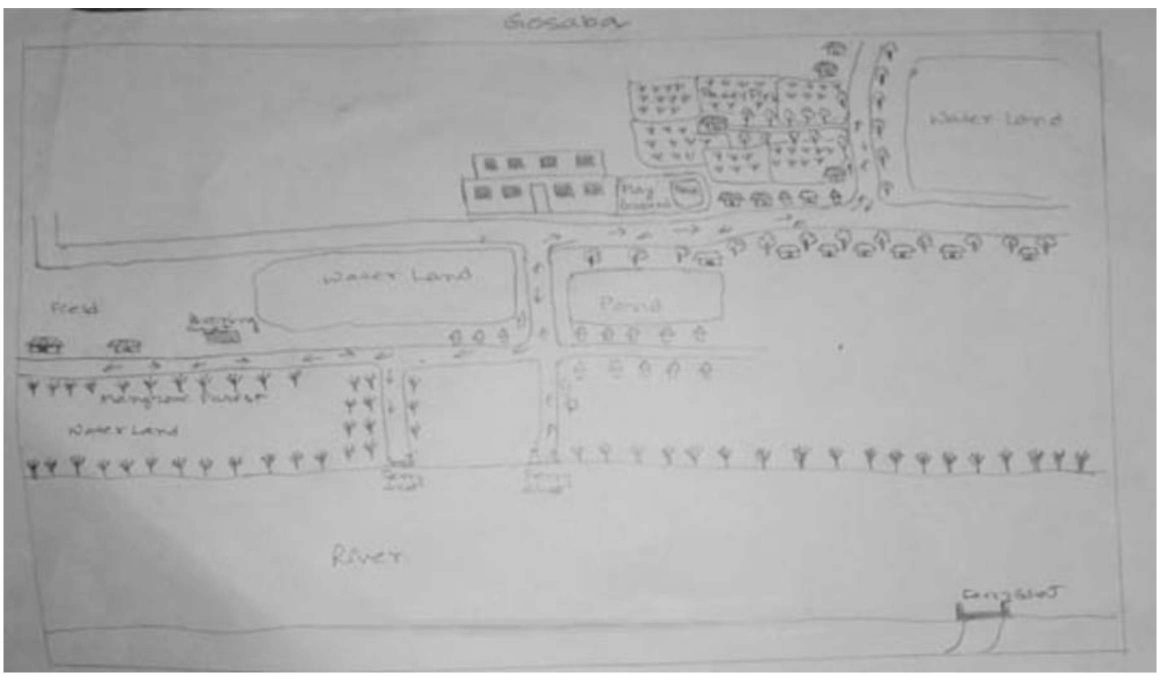

Figure 1: Resource Map of Dayapur, Gosaba

iv) Individual interviews: We have interviewed and involved group discussion with the villagers. Then the data have been collected directly from the villagers for building rapport.

RESULTS

Table 4: villagers' perspective on agriculture- based livelihoods in different villages of Sundarbans

Village	Primary Livelihood	Secondary Livelihood
Dayapur, Gosaba	Agriculture (mono -cropping, Aman/ monsoon pa ddy) including greens and vegetable cultivation in agricultural field.	Catching prawn, fish and crabs from estuarine rivers and creeks, honey collection and wood cutting from forest, d ate tree cutting, sap collection and treacle making, working as labour, animal husbandry, service in cities
Durgagobindopur, Patharpratima	Agriculture and agricultural wage labourer.	Catching prawn seedling, fish and crabs from river and creeks, honey collection and wood cutting from forest.
Amarabati- Lakshmipur Abad, Freasergaunj	Fishery and pisciculture in pond, prawn culture in bheri, collection of fish from Bay of Bengal.	Agriculture (double cropping, Aman and Boro), kitchen gardening, animal husbandry, sap collection from date tree and making treacle.

Livelihood related to fishery as per villagers of Fraserganj - A list of the major fishes commonly grown in fishery and their selling prices are given below-

Table 5: Major Fish Commonly Grown in Fishery

Name	Time Required to grow up	Selling Price (Rs.)
Tiger Prawn	3 Months	400-600/Kg
Harina Shrimp	3 Months	120/Kg
Chemana Shrimp	-----	-------
Bhetki	4-5 Months	60-70 To 150 -200/Kg
Perse	--------	150/Kg
Bhangar	4 Months	400- 500/Kg

Livelihood related to mangrove forest as per villagers of Dayapur, Gosaba

I) Bee- keeping: Collection of honey produced naturally in the forest by wild honey- bees. Quality of honey depends on the major forest trees. Here is a list of major forest trees and their quality of honey.

Table 6: Trees and their Quality of Honey

Name of the tree	Quality of honey
Khalsi	Transparent
Garan	Next to Khalsi
Kaora	More or less like Khalsi
Bain	Bitter and pungent in taste with an undesirable smell
Geon	Alike Bain

I) Wood cutting: there are a number of forest trees those are valuable to the villagers.

Table 7: Useful Forest Trees and Their Uses as Per Villagers' Perspective of Dayapur, Gosaba

Name of the trees	Primary uses
Garan	Fuel, frame and post of house, fencing, making granary for paddy
Posur	Boat making, post of house, door and window and furniture making
Dhudul	Best wood for making furniture
Golpata	Used for thatching roof.
Kaora	Not used as wood. Its fruits sale in market
Hental	For making mats

v) Group discussion and formulation of action plan:

Formulate an action plan

1. The restoration of soil health essentially needs to improve the agricultural production of the study areas.
2. Proper management of drainage system, rain water harvesting to improve irrigation, regular training of farmers to cope with modern techniques of agriculture.

CONCLUSION

Economy of Sundarbans is built mainly on agriculture, fishery and forest resources. The region is not industrially advanced. Agriculture mainly mono-cropping. Rural people are mostly landless who sustain themselves by collecting and selling forest produce such as timber, honey, wax by catching prawn seedlings and selling them to the Bheri (fishery) owners; and by working as wage labourers. Generally, two months during rainy session (Asarh – Sravan) provides employment to the people of rural Sundarbans (Mandal, 2019). Men remain unemployed for almost rest of the months in a year. Women to some extent get works on contract obviously, people need to go outside in the neighboring districts for work, enter inside the forest for pursuing livelihoods or borrow money from money lenders. Besides agriculture and forest, other sources of livelihood include 'jalkar' (land given on lease for fishery); agricultural labourer, animal husbandry, kitchen gardening; construction and repairing of huts; cottage industry; business in transportation, catching fish; prawn seedling; crabs etc,

The primary purpose of this study was to foreground the challenges faced by the farmers of Sundarban. Undoubtedly, agriculture is the economic backbone to sustain the basic livelihood of rural people. Increasing salinity, waterlogging, lack of irrigation facility and lack of skills about diversified agricultural system. Climate change makes the situation more challenging for farmers to sustain their livelihood through agriculture. Therefore, modern techniques of agriculture, regular training and proper management of drainage system are urgently needed to improve their livelihood.

Therefore, a comprehensive time- tested model of research and development with active participation of local people considering the socio- economic and ecological feasibility is needed to bring changes in the lives of the villagers of Sundarbans.

Fig 2: Meeting with Pradhan of Frasergaunj GP.

Fig 3: Meeting with Pradhan of Pathar Pratima

Fig 4: Interaction with villagers at Amrabati, Frasergaunj

Fig 5: Learning by interaction with local people of Gosaba

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Chapter 18

Issues and Challenges in Innovation in Science Education

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Issues and Challenges in Innovation in Science Education

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ABSTRACT

The main aim of Science Education should not become industry of the production of Scientists of tomorrow. With the degree of advancement of Science, we are facing burning problems such as global warming, greenhouse effect, energy resources, food production, genetic modification, and Societal Challenges. So, we should develop candidates suitable for solving such type of problems. But the research facility and research are almost zero at the College level in West Bengal also College teacher facing problem from College and University to become a supervisor or Guide.

Keywords: *Innovation; Science Education; Research; Schools; Colleges; Universities*

INTRODUCTION

Research and Innovation in Science Education should be research oriented approach and it is especially important for the development of a Country. Our India, the second largest in democracy and lowest in quality of research and education till now. Why are number of researchers are found from China and America? Because we are poor in quality of education and research in the World. The decrease of quality in education and research is due to corruption and political involvement in Educational and Research Institute. The research in Universities became routine without any new innovations in India mostly in West Bengal. Among the top 10 Universities in research and teaching in the World, 8 are found from America. Among the top 100 Universities in the World, 58 were found from America. Among top 200 Universities, we have one or two in the world. This indicates that the Central Universities and IITs of India became fascinating and style Institutes without any quality because some Criminal like people who don’t know the value of the public money are running such Institute with political influence.

REVIEW OF LITERATURE

Research in colleges

The research in Science in Colleges in West Bengal is almost zero. It is a big shame to the Science Professor and Principals of the Colleges. The research culture in College is very minimum. The teaching capabilities are satisfactory for these teachers. If research is added to these teaching teachers, the performance of the teachers increases. The Science teachers should apply to Major and Minor Research Projects and investigate accordingly. The Principals should encourage for applying research Projects, though our principal Sir in Surendranath College doing this now. They should not harass the Teachers who are pursuing research. The Principals should not expect any commissions and money from the Principal Investigators. The Science teachers should do research for increasing their career and big name and fame to the Colleges. They should do research without any fake quotations and bills. The University Grants Commission should be strict in monitoring the research projects. The research projects should be new, interesting, and useful to the Society. The eminent teachers are not having guideship for guiding the students in research. This is due to much fee for guideship. The Science Teachers should participate and present papers at Conferences, Seminars and Workshops. The knowledge will be exchanged among teachers if they participate and present papers. The research in Indian Institutes and Indian Universities is not satisfactory. They are producing routine publications without any quality. The Indian Scientists and Professors are increasing number of publications without any quality. They are doing Research for their personnel benefit. They are getting big amounts as Commissions and other means without purchasing equipment, books, Journals by putting fake bills etc. The Scientific bodies such as UGC, DST, DBT etc. are allotting huge funds those who give big amounts as commissions. If this is the situation, how our Country develops in research. Before Independence, the quality of research is good and now it has deteriorated continuously. See for example in Physics, Sir CV Roman was awarded Nobel Prize in Physics on February 28, 1928 and received it on February 28, 1930. He discovered Raman effect with a simple spectrograph whose cost is just Rs.200. After independence, no Noble Prize in Physics is given unto date for Indians. In olden days, a lot of commitment, honesty and integrity is present. These were absent now days and deteriorated the quality continuously. The Government of India has allotting lakhs of crores of amount of budget to the India Scientists and of no use in producing single prize of world recognition. This clearly indicates the Scientists and Professors of India arc not honesty. We have 54 central Universities and 23 IITs in India as per Google search [2020]. These Institutes do not occupy any place below 200 rank except Bombay (162 in 2019) and Delhi (172 in 2019) in the World regarding teaching and research. These Institutes became style institutes without any quality. We have hundreds of states, deemed and private Universities. We have thousands of Colleges in public and private sectors in India. We have some colleges with autonomous status and with center for potential excellence. No one College or no one university is of International Standard. Chicago of USA has Occupied world number one position in teaching and research since it has produced more than 126 Nobel Laureates as per Google search [2020].

Research in learning

We need to form science education effective and relevant for an outsized and additional numerous fraction of the population. The hypothesis that we tend to et al. have advanced is that it's attainable, however providing we tend to approach the teaching of science sort of a science in an exceedingly ancient science category, the teacher stands at the front of the class lecture to a for the most part passive cluster of students. Those students then explode and do back-of-the-chapter schoolwork issues from the textbook and take exams that square measure virtually like those exercises. abundant analysis has been conducted on this pedagogic strategy, whereas the information mentioned here were gathered principally in introductory faculty Science courses, the results square measure according to those of comparable studies worn out different scientific disciplines and at different grade levels. The results are also per what we tend to all understand knowledge (Ball *et al.*, 2008). There ought to be fascinating in Science Education with experiments and analysis (Jessani, 2015).

Understanding concepts in science

The Physicists believe that one in all the nice strengths of physics is that it's a couple of elementary ideas which will be applied terribly wide (National Research Council, 2002). This has galvanized physics education researchers to review however well students are learning the fundamental ideas in their physics courses, significantly at the introductory level. most likely the oldest and most generally used assessment tool is that the Force ideas Inventory (FCI) (Hestenes, 1992). This wonderful instrument tests students' mastery of the fundamental ideas of force and motion, that are lined in each 1st semester post-secondary physics course (Wieman et al.,2008). It needs students to use the ideas of force and motion throughout a real-world context, like explaining what happens once a automotive runs into a truck. The FCI currently administered in several courses annually commonly is given at the beginning and finish of the semester to determine what proportion students have learned throughout the course. Richard Hake (1998) compiled the FCI results from fourteen completely different ancient lecture-based courses and located that students down not quite half-hour of the key ideas that they didn't already recognize at the beginning of the course.

Institutional change

We currently have smart knowledge showing that ancient approaches to teaching science don't seem to be undefeated for a colossal proportion of our students, which we've got some of research-based approaches that deliver the goods far better learning (Hake, 1998). The scientific approach to science teaching works, however, can we create this the norm for each teacher in every room, instead of simply a collection of experimental projects? we tend to believe modification ought to initial occur at major analysis universities, as a result of those institutions set the norms that permeate the education system regarding but science is schooled and what it implies that to seek out science. Moreover, their departments manufacture most of the college teacher’s global organization agency then go onto teach science to the majority of school students, yet as future schoolteachers. These learning outcomes cannot be obscure generalities however rather should be specific things they have students to be able to try this demonstrate the required capabilities and mastery, and thus will be measured in a very comparatively easy fashion for assessing the outcomes should meet sure objective standards of rigor and be jointly set and employed in an identical manner, as is completed in research many obstacles hinder modification within the current system (Wieman *et al.*, 2008). First the present association between the incentives within the system and student learning is weak. Several believe this can be thus as a result of analysis universities and their college don't care regarding teaching or student learning. We can not disagree most instructors do so care an excellent deal regarding student learning the important drawback is that we've nearly no authentic assessments of what students learn, thus it's not possible to broadly speaking live that learning and likewise not possible to attach it to resources and incentives. The second obstacle to alter is that whereas we all know the way to develop the mandatory tools for assessing student learning in a very sensible, widespread approach at the university level. Carrying this out would need a major investment. Introducing effective research-based teaching all told school science courses for example, developing and testing didactically effective materials, supporting technology and providing for college development would conjointly need resources. However, the consider R&D and therefore the implementation of improved instructional strategies at the most universities is basically zero. Additional typically, the political can on field to originate cultural modification on these lines is absent.

CONCLUSION

The Science subjects ought to be incontestable through experiments. These subjects ought to be let alone potential analysis. Our society faces each a demand for improved science education and exciting opportunities for meeting that demand. Adopting a additional studious approach to education that's, utilizing analysis on however the brain learns, effecting careful analysis on what students are learning, and adjusting our tutorial practices consequently has nice promise. Analysis vividly documents the failures of ancient strategies and so the prevalence of some new approaches for student learning. The challenge is to develop a mental attitude that teaching ought to be pursued with the same rigorous normal of scholarship as research. Higher education's leaders will facilitate build that happen by cultivating the political can implement simpler pedagogic approaches to learn each student in each school and university.

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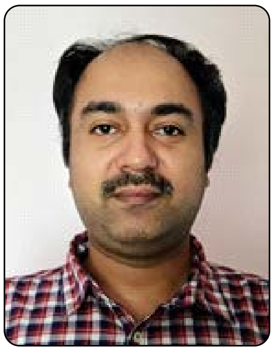
Chapter 19

Fruit Chromophore Selection for Reactive Modification of Plant Biopolymer Exudate and its UV-VIS Study



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Fruit Chromophore Selection for Reactive Modification of Plant Biopolymer Exudate and its UV-VIS Study

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ABSTRACT

Polysaccharides are an important class of biopolymers. The immense relevance of the biopolymer/polysaccharide to be used as energy storage unit of plant and animals, suggests it to be a superior alternative over synthetic polymers. A biomaterial possesses minimum side effect and hence being used as dietary supplement and therapeutic agent. We attempt to develop pH modification through fruits grape, orange and tomato in a degradable biopolymer gum acacia. This modification is then exploited to observe the visible light response capability of the developed polymer and choose the best suitable fruit showing better response.

Keywords: *Biopolymers; Sol-gel process; Chromosphores; Absorbance Spectroscopy.*

INTRODUCTION

Environmental problems have loomed over large all over the world from centuries due to higher usage of vehicles, electronic gadgets, synthetic dyes and many other pollutants. But human race has no way to decrease their ever-growing demand. Therefore, for the sustenance of civilization these two opposite phases need some compromise from both ends as well as development of new material from the womb of our mother earth. These materials will be the green and clean alternative of their synthetic counterpart and is called “Biomaterial”.

A special kind of biomaterial is ‘‘Biopolymer’’. They deteriorate and degrade via different microorganisms and other processes. Biopolymers possess the synonymity of iteration process in computation on plant materials, but they do not extinguish and can be used in for preparing green materials in different industry due to their non-toxicity, low immunogenicity and good biocompatibility (Sigel *et al.*, 2008). These polymers decrease carbon emissions in the atmosphere. Long term use of biopolymer limits fossil fuel usage. Biopolymers which are emanated and/or derived from various plants have several activities in pharmacy as well as pharmaceutical and in biomedical applications like hydrophilic drug carriers, cosmetic and paint industry, in preparation of food products like low fat foods (e.g., spreads and soft cheeses). (Williams *et al.*, 2006). Several names of polymers come out from the family of Acacia Senegal origin mostly from Sudan. Natural gums have different sources of origin viz. microbial, plant and animal. They are non-toxic, bio-degradable and wide availability of resources makes cost effective over synthetic biopolymers (Vroman & Tighzert, 2009). In food industry they are used as thickening agents and stabilizers. Plant gums are usually hetero polysaccharide. Modification in the chemical structure is the gateway of accessing application in different scientific fields specifically in food and medical industry. (Jayakumar *et al.*, 2005).

Gum Acacia are found and processed from different group of Acacia tree. They are amorphous and possess high viscosity. It does not dissolve in organic solvents but has high water solubility (50% w/v). The water solution is mild acidic with pH~4.5. (Montenegro *et al.*, 2012). This plant polymer is used as basic components in dairy products, beverages, confectionery, textiles, paints, pharmaceutical and cosmetic products (Rabek, 1987). Gum Acacia is a negatively charged, water loving, zero toxicity, complex polysaccharide with branching in its chemical composition (Grein *et al.*, 2013). Apart from these, Gum Acacia is being used extensively in medical world (Beneke et al., 2009) and in nanotechnology (Patel & Goyal, 2015). Appropriate measure of chemical activity taken with this natural polymer creates ionic Gel formation which may be used for practical implications of a cell (Mallik & Sarkar, 2006).

In this work we describe the synthesis of gum Acacia biopolymer by probable conjugation in its chemical structure with weak acid dispersion from grapes with rich pigment *(Vitis vinifera)*, oranges *(Citrus reticulata)* and tomato *(Solanum lycopersicum)*. Chromophores contained in plant develops colour when they absorb radiation within visible range of spectrum. They are conjugated unsaturated bonds. Chromophore is the region where radiation is absorbed and transfer electron between two energy states. In the present work optical properties of pure specimen and chromophore induced specimen are examined. Absorption of light in the green region of visible spectrum is profound for grape chromophore modified gum Acacia biopolymer. The modified biopolymers exhibit improvement in ability to absorb light in visible spectrum range. Due to lowering of band gap of the modified biopolymer, more number of electrons are available for HOMO-LUMO transition. Absorption occurs at higher wavelength compared to the unmodified gum Acacia biopolymer.

METHODS

Specimens are prepared from processed Acacia biopolymer in powder form (LOBA). Hydrated solution of this polymer is done by mechanical stirring in deionised water of high value of resistance taken from Millipore System. Stirring is done at above room temperature (330K) for 1 day. Rich colour grapes, oranges, tomatoes with pH between range 2.8–4.7 are taken for dispersion in Acacia solution after proper treatment of washing and grinding. The resulting dispersed solution is prepared at 350K and then preserved in air tight containers for formation of complex. After one day the solutions are poured on glass slides of experimental quality. Then they are annealed in a heat chamber at 360K to remove any residue of water. Then UV-VIS spectroscopy is done for all prepared samples in Perkin Elmer 25.

RESULTS AND DISCUSSION

Chromophores and electronic transition

Biopolymers are inferior compared to synthetic polymers in context of mechanical strength as they become brittle at low temperature and pressure. Their properties could be improved by achieving property combinations required for specific applications. Gum Acacia biopolymer is amorphous (Mallik *et al.*, 2002). The absorption of radiation is observed in the lower wavelength region at 300 nm. This occurrence is due to high band gap value of the pure biopolymer. The absorbance observed (absorbance in a.u. vs wavelength in nm) of as prepared Acacia specimen and after annealing are shown in Figure 1 and Figure 2. The peak observed in low visible wavelength is supposed to the

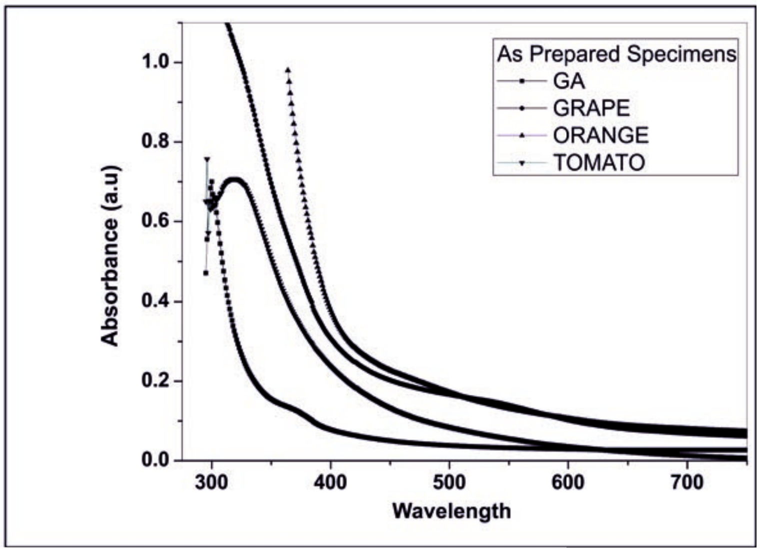

Figure 1: UV VIS Spectrum of as Prepared Gum Acacia Biopolymer Modified with Fruit Chromophores

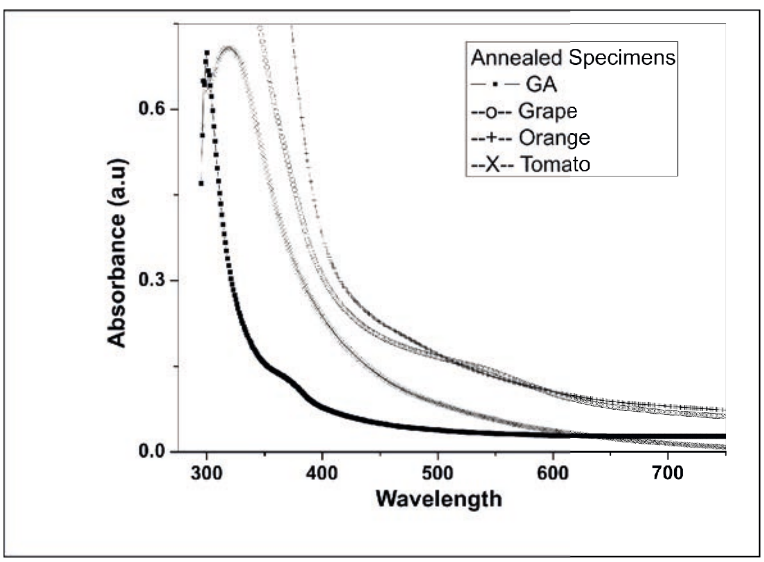

Figure 2: UV VIS Spectrum of as Prepared Gum Acacia Biopolymer Modified with Fruit Chromophores

conjoining of its arabinogalacton components. (Xue *et al.*, 2002). Electromagnetic radiation absorbed by electrons of a organic compound occurs in chromophores which causes transition from lower energy state to higher energy state. It alters distribution of the electrons (particularly the external electrons) in the molecule. Chromophores possesses π electrons and heteroatoms. Radiation absorbed at the end of the visible range of spectrum make variation in the distribution of electrons in molecules which makes electron movement from a bonding σ or π orbital or a nonbonding n orbital to an antibonding σ^* or π^* orbital (Rabek, 1987). The energy of transition increases in the following order: $(n\rightarrow\pi^*) < (n\rightarrow\sigma^*) < (\pi\rightarrow\pi^*) < (\sigma\rightarrow\sigma^*)$. The stimulation of electron is due to vibration, rotational and translation excitation. Excitation from σ to σ^* requires absorption of radiation in the deep ultra violet wavelength. π to π^* and $n\rightarrow\pi^*$ excitation is responsible for absorbance in the UV-VIS range. The bands for gum Acacia are assigned to the $n\rightarrow\pi^*$ electronic transition (Binitha & Sunugan, 2008).

Absorption spectra

The observed UV-VIS absorptions of pure gum Acacia specimen is not within the visible range (as shown in Figure1 and Figure 2). So, this specimen could not be used in visible light driven application in its pure form and hence not possible to use solar energy. Therefore, utilization of chemical route was implicated in interaction with weak acids such that the modified specimen may absorb radiation in the visible range of spectrum. The solvent influences the positions of absorption bands. The solvent increases polarity causing red shift in $\pi\rightarrow\pi^*$. The gap between ground and excited energy levels is decreased due to attractive force of electrostatic nature within absorbent and solvent. Decrease in energy levels for excited state is more than lower energy state causing decrease in gap between the two energy levels. This effect results red shift of the absorption band to higher wavelength. Molecular weight of aqueous solution of gum Acacia is increased due to occurrence of polymerization process. (Katayama *et al.*, 2006). As conjugated π systems become larger, the collection of radiation is broadened, the difference of energy level for π to π^* movement becomes shorter, therefor absorption of light occurs in the higher side of visible range of radiation. As conjugated π systems become larger, the collection of radiation is broadened so the separation of energy level between π and π^* levels become thinner so the red shift occurs which is known due to shift of absorption of radiation in larger wavelength of light.

Figures shows absorbance spectra of chromophore modified gum Acacia specimen as prepared and after annealing. Modifications being done with chromophores of Grapes, Oranges and Tomatoes. Absorption of radiation is observed in the visible region (~550 nm) alongwith 30 nm red shift is observed in the Tomato chromophore induced annealed sample.

Naringin and hesperidin, so-called citrus flavonoids, are the two main glycosidic flavanones presented in oranges (Tokuşoğlu & Hall, 2011). Flavonoids and hydroxycinnamic acid are also major components present in tomatoes. (Toor *et al.*, 2005). But their presence does not influence the required red shift in uv-vis spectrum.

Phenols and other organic compounds present in rich coloured grapes regulate the colour composition of the compound. These compounds are possessed of Anthocyanins and Tannins. Anthocyanins are pigmented compounds found in grape skins (Lorrain *et al.*, 2013). Changes in pH cause structural transformations in anthocyanins molecules, which effects the colour of the pure gum Acacia specimen. Also, the presence of π electrons and the coupling of double and triple bonds with lone pairs are responsible of absorption of radiation in the long visible wavelength region.

Tannins are large molecules which polymerize. Grape seed tannins interact with proteins increase with the degree of polymerization (He *et al.*, 2015). This polymerization increases molecular size (Xia *et al.*, 2015). Electrostatic force of attraction between solvent and chromophores in the dielectric medium scale down the states of bonding and antibonding. Lowering of antibonding state is more than bonding state, so the difference of energy level between both of them is now smaller. So, the energy required for the transition between the bonding and antibonding state is lowered causes higher wavelength so lower value of energy is required to promote HOMO LUMO transitions at higher wavelength radiation – which causes red shift (π to π^*) transition.

CONCLUSION

Low cost sol-gel technique has been utilized for preparation of pure and modified gum Acacia polymer. The as prepared gum Acacia solution shows the transition in the radiation of energy in the ultraviolet range of spectrum. Orange and Tomato chromophore modified gum Acacia do not show any profound effect of absorption of visible range of radiation but the pure solution when modified through the pigments presents in the rich coloured black grape shows marked absorption. Intensity laof the uv-vis spectrum is enhanced because of annealing. The synthesized biopolymer has utilization in DSSC, Polymer Electrolyte and other branches of material science.

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Chapter 20

Revolutionizing Science Education Through Virtual Laboratories

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Revolutionizing Science Education Through Virtual Laboratories

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ABSTRACT

Virtual labs are now extremely popular in modern science education because they provide an alternative method of learning and teaching hands-on science while remaining in the comfort of one's own home. According to Anderson et al., (2020) this was much needed, as traditional in-person classroom teaching-learning and hands-on practical courses had to be suspended for months after months in various countries around the world due to the COVID-19 pandemic situations and inevitable shutdowns. These modern virtual laboratories are a one-of-a-kind technological innovation that can provide new learning environments for all Science, Technology, Engineering, Medical (STEM) educators and students. Simulation-based virtual labs can also be beneficial to a group of potential researchers, who can really play a critical role in bioinformatics and related subjects to effectively accelerate high-threshold translational research. This virtual lab initiative is expected to usher in a paradigm shift in traditional science education, almost completely replacing current educational institutional labs and hands-on practical curriculum. The exploitation of sheer affordance of this unique approach has the potential to significantly expand science education worldwide. These types of innovative and trailblazing initiatives for distributed learning with virtual labs would undoubtedly benefit the entire world of students, scientists, and educators alike. The current paper will address the topic issue by highlighting the main themes: what a virtual lab is, its main objectives, functions, need, and finally, its scope and the real reason, why it is gradually becoming so relevant and important even from an Indian perspective.

Keywords: *Virtual laboratory; Technological innovation; STEM; Simulation*

INTRODUCTION

Amazingly irresistible nature of Covid and the unavoidable social separation and lockdown following it to forestall its fast transmission at the local area level, constrained each day in-grounds instructing and active research facility courses to get suspended in endless schools, colleges and universities worldwide for a vague period (Anderson *et al.*, 2020). Be that as it may, notwithstanding every one of these things, the progressive headway in current data innovation helped us all to remain very much associated while working from the security of the home. Instructive executives truly endeavored to guarantee that the teaching-learning of the educational program, albeit interfered, should not stop absolutely during this unlimited emergency period. Scarcely some regarded establishments and colleges everywhere on the globe made a decent attempt to conquer this serious emergency by changing or moving the important instructive materials into virtual mode. Far off learning approaches including live streaming, online courses, virtual educating, and mimicked labs assumed an urgent part in that specific situation.

Be that as it may, aside from this Covid issue, an extra old test looked at by the science, innovation, designing, and clinical (STEM) instructors have consistently been the mixing of Inquiry-Based Science Education (IBSE). As of late, this IBSE method has ended up being powerful in educating by guaranteeing dynamic support, considering all aspects. According to Fischer *et al.*, (2007) these IBSE strategies alongside the help of present-day computerized advances can clearly assume a crucial part in getting a sensational change in the whole instructive framework and virtual research facilities can go about as a key computerized device in this cycle. If we can truly give every one of the understudies all throughout the planet the ideal admittance to such virtual labs, it would clearly certify and energize a totally different age of promising youngsters to pioneer and transform in turn the whole world.

REVIEW OFLITERATURE

What are virtual laboratories?

These are laboratories with a proper interactive environment for the creation and conduction of simulated experiments. It involves proper conduction of experiments with domain-dependent simulation programs. Utilizing virtual reality technology, a virtual laboratory typically tries to simulate the processes and actions normally performed in physical laboratories in much cheaper ways for the students at all schools, colleges, and universities, for all science courses. According to Alexiou *et al.*, (2004) these remote laboratories offer their users, especially teachers and students, real learning experiences that might be impractical in physical classrooms. Users can design, develop, and achieve pre-determined experiments there, that simulate experiences and processes in a real-world environment. In these laboratories, all the students can be simultaneously made involved at a particular time and actively participate, unlike the physical systems where only a few students can in fact get the chance to do the same and learn while their other batch mates remain mere spectators. Effective use of simulation in virtual labs can truly make things much interesting.

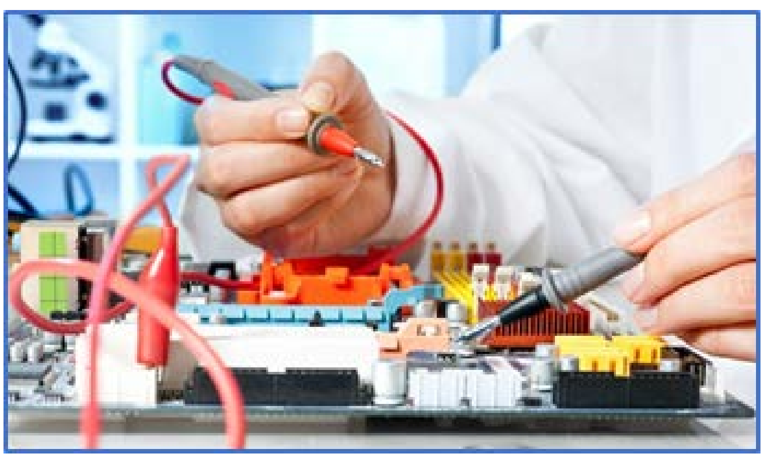

Figure 1: Virtual Electronics Lab

What is simulation? We generally define simulation as non-static representations of physical phenomena; that is, representations that seek to show the movement of elements that build up a physical phenomenon. We can simulate different experiments used in science, engineering, and medical curriculum exactly following the experimental principle, conditions, procedure, data, and finally conclusions. All these points are taken care of meticulously in each virtual experiment. Simulators can create an interactive visual demonstration of various techniques. While in conventional labs, students have only a brief time to assimilate lessons, virtual labs provide unlimited access to class materials, thus facilitating a far better understanding of the topic. Although virtual labs cannot replace hands-on training yet now, the wise use of interactive simulations can provide the scholars thought of what to expect within the real lab, thus lowering the time spent in learning completely new methodologies.

Main motto and building of virtual labs: These virtual labs can literally join theoretical knowledge to practical applications during a lab set-up to provide ultimately a safe learning environment, where individuals can learn from iterative practices, at their own pace, without any potential risk, despite using any costly chemicals or equipment. Although these resources cannot be expected to put individuals on an equal footing with those who have real-world experimental hands-on training. However, in these platforms students can get a true feel of what to expect in real-life experiments, acquire the requisite knowledge behind the experiment, and apply these concepts in physical labs in the future. They have already been proved to reinforce student learning experiences when utilized together with other IBSE teaching-learning methods. It is found from research that students can preserve more information when audiovisual methods like virtual labs are used effectively to make the classes mutually interactional and reciprocal thereby impelling students to actively participate. According to de Jong et al., (2013) building of virtual labs involves sequencing of varied experimental steps using proper modeling bringing effective visualization for simulating actual reality. Variation of different parameters is intelligently done to model actual lab behavior in proximity and to recreate not only the realistic output but also the true feel of the real wet lab experiments (Keller *et al.*, 2005).

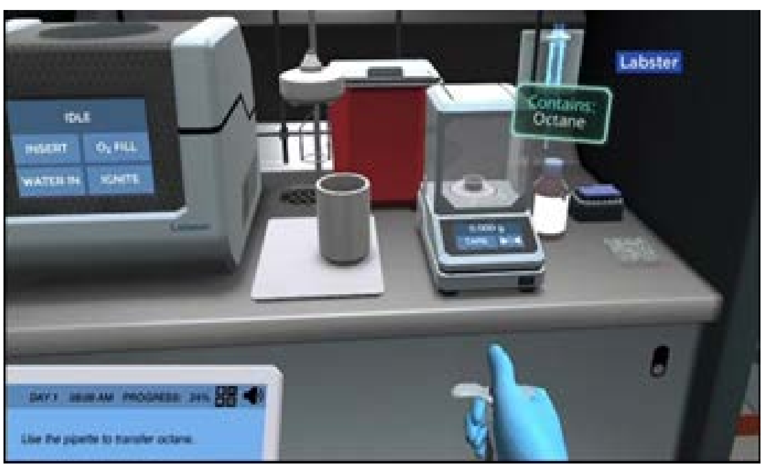

Figure 2: Virtual Biology Lab

Why virtual labs? To assure overall global opulence, the planet desperately needs more and more skillful and enthusiastic children who would regard science as their future career. To achieve this, drives are needed that will really capture science students in enthralling and stimulating science experiences. This would require initiatives at the policy level worldwide to forcefully introduce an inquiry-based approach to education, involving all the educators and ensuring equal commitment of other stakeholders like science laboratories, National Educational Committees, etc. Apart from this, it is also a bitter fact, that STEM graduates nowadays are in brief supply everywhere on the planet. With alarmingly decreasing college enrollment, this is often really a troublesome job to combat the insufficiency of STEM graduates. But it is not at all an easy feat to tantalize and make the students stuck to STEM career paths with the help of traditional methods (Waldrop, 2013). It was proved to be ineffective. Thus, shooting up student excitement for STEM careers is now the only solution to counter the thriving lacuna of adept science graduates and virtual labs work with this sole target of accelerating student engagement and excitement in STEM learning.

Objectives of virtual lab: According to INSIDE HIGHER ED, there are so many objectives. Some of them are summarized below:

1. To supply far-off admittance to labs in different controls of science and innovation.
2. To urge understudies to perform tests by arousing their interest.
3. To supply a whole Learning Management System around the Virtual Labs where the researchers can get to different instruments for learning, similar to additional e-assets, supporting video addresses, energetic shows, and an adequate chance of self-appraisal and assessment separated from playing out the actual examinations.
4. To impart to all relatively costly hardware, essential synthetic compounds, and assets, that are generally accessible to a predetermined number of lucky clients simply because of time imperatives and topographical locational drawbacks.
5. To make things powerful and sensible by giving extra contributions to the researchers like supporting general media gushing of a genuine lab test.
6. To supply demonstrating of any characteristic wonder for performing reenactments appropriately to yield a similar outcome as of the real trial.
7. To supply previously estimated information (recently recorded) for different examinations by genuine estimations on the genuine frameworks.
8. To distantly work any test in a genuine actual lab and furnish the understudies with the genuine information of the examination through a PC interface.

Figure 3: Virtual Chemistry Lab

Existing sample virtual laboratories (worldwide): There are so many such laboratories like MERLOT, Molecular Workbench, Labster etc. They provide access to a realistic experience that allows students to perform experiments and practice their skills in friendly and risk-free new learning environment. With more than a hundred such open-source free virtual laboratories, students from different standards can now watch videos, perform experiments again and again at their convenience for better assimilation. There are so many such type of running projects all over the globe. For example, the Go-Lab project tries to furnish a collection of online laboratories containing virtual experiments and thereby helps the educators to implant these online labs in pedagogically designed learning environments. The UniSchooLab project comes up with an online package mainly for schoolteachers for availing high quality university-grade science laboratories remotely for generating inquiry-based learning activities of students. PHET, Library of Labs, Labshare, Open Sources Physics, Smart Science, Molecular Workbench, Explore Learning, Chem-Collective, Remotely Controlled Laboratories (RCL), Skoool, iLab-Central, Lab2Go, WebLab Deusto are only a few examples from the long list of existing laboratories. Such types of online lab are widely available in a variety of subjects that can be found in Online Labs in. (2009).

How do virtual laboratories engage students? Virtual labs are in real sense replications of real wet labs, available to the user through a computer screen or a VR headset and an internet connection. These simple toolkits truly permit STEM students to experiment even in highly sophisticated labs at dirt cheap price compared to a real wet lab. The engaging 3D animations, and following principle, theory, quizzes etc. using special simulation techniques help students to get better perception and comprehension of rather complicated concepts. In these labs, a student can accelerate time to see the experimental results rapidly, revert again to rectify the committed faults, and redo the same repeatedly to fully understand the subject. All these things together can make students experience truly engaging, and a real fun. Past studies have shown that students can learn twice as much with these virtual labs. Many institutions all over the world are hence utilizing these labs today to prepare their students for practical lab exercises, to consolidate students' understanding of material after practical, and to help them to study for the exams. Beside these student benefits, it is equally beneficial for the educators too for effective teaching.

Types of virtual laboratory: There are various categories of virtual labs available (Bose, 2012). Some of them are described below.

Simulations: These are computer-based imitations of operating systems that represent a process based on a model that is cheaper, faster, less risky, and more affordable than the actual process.

Network applets: These are small virtual laboratories with popular experimental devices. They are small, portable, and can be operated irrespective of the operating system.

Virtual labs: They simulate a virtual operating system by leveraging the potential of modern media technology, that focuses on technical interaction and reasonable makeover of various objects and parameters.

Virtual reality laboratories (VRL): These entirely computer-based labs are extremely interactive. The user is here a partaker in a "virtually real" world, in a 3D digital environment.

Remote labs: These are real labs that can be controlled remotely and are known as online labs or workbenches. They include real-world experiments conducted from a distance using telecommunications while the user is in another location. For speed and security reasons, majority of these virtual laboratory software consists of computing applications that though run on the local user's computer but can be operated remotely.

Virtual laboratory vs physical laboratory: Compared to the limited space offered by physical workstations, virtual laboratories can be used with display technology such as interactive projectors or smartboards for an all-inclusive class (Widodo et al.,2017). They can complement existing ones or can be used as stand-alone, especially for courses where physical laboratories cannot be developed due to lack of resources and actual practices. Virtual laboratories are even more appropriate, significant, and cost-effective for educational institutions especially in developing countries where physical facilities are ill-equipped and somewhere even non-existent.

Working principle of virtual laboratories: In general, a typical well-designed modern virtual laboratory begins with the concepts regarding principles, fundamental experiments, and models for studying the universal principles of various science subjects. The concepts are followed by animations, galleries, audios, videos, live demonstrations, practices, and problem-solving approaches. Dynamic assessments and feedback mechanisms are also cleverly incorporated that in turn allow students to mentally map the experiments to prove, confirm and-or test their own understanding. Workbenches with resources and instructional guidelines for calculations are also built within as may be required for example in any titration experiment in chemistry. Each laboratory ends with definite bibliographies and hyperlinks to other resources for further serious studies. Students can easily bookmark these virtual lab sites and add them to their course portfolios. Not only do the students learn the principles behind these experiments, and can do them themselves, but sometimes they also get to experience the experts in action adding more value to their virtual experience.

Empowerment mission: Virtual labs can assist teachers in becoming more effective by increasing their impact and decreasing their workload over time. This is made possible by collection of tools made available to educators who use such laboratories. Another goal is to enable more students, regardless of geographical location, time constraints, or financial constraints, to pursue a science degree. It is also planned to add more features in future to these labs in order to make them smarter, such as personalised interface for each student and providing teachers with recommendations for each student based on their individual performance records. However, there are always some challenges in implementing such labs in schools especially because teachers must first be trained on how to use them effectively. Some teachers frequently refuse to use it also, preferring to use traditional methods, and some schools on the outskirts cannot afford computers and internet. However, the government should investigate this matter seriously, come forward to resolve these issues, and assist this virtual lab initiative in effectively empowering a whole new generation of teachers and students.

Educational democratization mission: Democratizing education entails making education more accessible and expanding learning opportunities for as many students as possible around the world. According to Hansen *et al.*, (2015) to access the entire STEM curriculum, particularly the practical portions, all virtual lab users need is a computer or a virtual reality headset and an internet connection. This enables remote students to learn from almost anywhere, as well as working students to learn at any time as needed. A personified and tailor-made approach to learning is thus offered considering individual learning styles and speeds. As a result, these simulations provide students with a one-of-a-kind opportunity to take their learning into their own hands, allowing them to learn on their own time, at their own pace, and in their own way. Students can freely explore laboratories, conduct experiments, study theory, answer quiz questions, and make mistakes without fear of repercussions in the real world. Their teachers can provide support while also facilitating their development to stimulate them to learn effectively. In other words, it is about empowering all students, including those from disadvantaged backgrounds, to reach their full potential. The ultimate motto of establishing these types of laboratories is to accredit students and teachers alike by boosting them to think differently about education, thereby revolutionising the way ordinary people think about it. More and more these types of labs grow and develop, more we will continue to learn how they can best provide students and teachers with the best, most effective and most engaging way of learning science.

Indian perspective and current scenario: The Ministry of Human Resource Development (MHRD), Government of India, initiated the “Virtual Labs” project as part of the National Mission on Education through Information and Communication Technology (NMEICT). The project's goal is to provide students at all levels, from undergrad to research, with remote access to laboratories in various disciplines of science and engineering and to share expensive equipment and resources, that are otherwise only available to a limited number of users due to time constraints and locational disadvantages (Virtual Labs). This project includes eight IITs (Delhi, Bombay, Kanpur, Kharagpur, Madras, Roorkee, Guwahati, and Hyderabad), Amrita University, Dayalbagh University, NIT Karnataka, and College of Engineering, Pune. Amrita University Mission's Virtual Labs are now available free of charge to all Indian institutions and students, and they are easily accessible via the website of Virtual Labs.

Figure 4: Govt. of India Initiative

Primarily this project has resulted in the creation of two categories of virtual labs. The experiments in the Simulation Based Virtual Labs are modelled using mathematical equations. The simulations are run remotely on a powerful server, and the results are delivered to the student via the internet. Virtual labs based on simulation are scalable and can support a large number of concurrent users. The actual experiments in the Remote Triggered Virtual Labs are controlled remotely. The results of the experiment (which is being carried out remotely) are communicated to the students via internet. This type of virtual lab provides the student with the results of real-time experiments. Timeslots are reserved before such experiments can be carried out. Only a PC and broadband connectivity are required for the user to access these Virtual Labs. According to Ray *et al.*, (2012) under this project, till date 85 Virtual Labs with a total of 769 experiments have been created. To disseminate information about these labs, trainings and workshops have been also held across India. A collaborative platform for virtual lab development has also been developed to assist faculty members with authoring and maintenance of these labs. Over 825 experiments developed by many of the partner institutions are also hosted on this platform. This collaborative platform provides the server-side architecture for virtual labs to run securely and effectively while serving thousands of students simultaneously, as well as reserving time slots for experiments that demand scheduling.

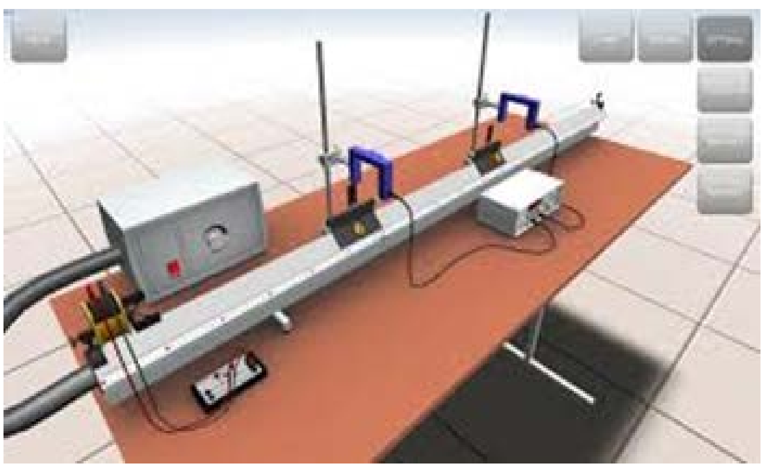

Figure 5: Virtual Physics Lab

They also furnish tools to assist teachers in monitoring the progress of their students and making desired changes to the instructional materials. For record, all these Indian virtual labs are based primarily on the Massachusetts Institute of Technology (MIT) iLabs.

Future scope: With the introduction of virtual labs, Indian students will definitely have easy access to a vast array of science and engineering knowledge presented in a captivating, interactive, enchanting, and utterly fascinating manner. These Labs will allow students to explore, discover, and learn wherever and whenever they want. The government hopes to provide access to those virtual laboratories to almost 5,00,000 students, bridging the digital divide between urban and rural teachers and learners and empowering those who have been left behind by the recent digital revolution. Students in Indian institutions will be able to access physical laboratories located thousands of kilometers away by using virtual labs. Students will also be able to submit the results of their lab activities for assessment and evaluation to the schools of the Indian Institutes of Technology (IITs) and other partner institutions and they also will be allowed to reserve time slots for remote-triggered labs ahead of time. While theory is frequently prepared offline, students will be allowed to conduct the experiments online, and these virtual labs will be able to accommodate 20 times more experiments compared to their physical lab analogues.

Figure 6: Modern Biotechnology Lab

They will be extremely useful for technical students, who do not always have easy access to necessary lab facilities. High school students' curiosity will be piqued, and young science researchers will be highly motivated to collaborate and share their existing equipment. International collaborations are also being considered. These virtual labs are unquestionably a solution to a large number of scholars' lack of access to expensive but primarily necessary scientific instruments, particularly in remote and economically backward institutions in India. Another critical issue that the government hopes to address through these virtual labs is the visible scarcity of qualified competent faculty in the educational institutions. Although the lack of reliable internet access in rural India will undoubtedly pose a significant challenge to the project, the merger of the National Mission on Education through NMEICT (Aarogya Setu App) and the National Knowledge Network in India is expected to connect approximately 572 universities. This could benefit nearly 15 million college students in India, who attend 25,000 colleges and huge number of polytechnics. These NMEICT, National Knowledge Network, and the government itself conjointly aim to provide high-speed internet and data transfer connectivity to all educational institutions throughout India, enabling e-learning, improving e-content repositories, and sharing of best practices. The Ministry of Human Resource Development (MHRD), Government of India, launched India's first comprehensive set of virtual labs as part of the "Sakshat" mission on education. According to Ray *et al.*, (2012) this project also includes several emerging sophisticated biotechnology virtual labs covering various areas of recent biological sciences. The virtual Proteomics Lab at IIT Bombay, the most modern of all simulation-based virtual labs in this project, aspires to freely share digital publications of high-quality research, as well as college and university-level educational materials related to proteomics (a newly emerging discipline of biotechnology), around the world. Finally, these virtual labs have the potential to become a gold mine in the Indian educational sector very soon.

CONCLUSION

Thus, a plethora of free virtual laboratories is at present accessible worldwide at secondary school, undergrad, and graduate levels to supplement getting the hang of, education, and research. For the individuals who enthusiastically accept that science (extraordinarily the involved things) and related courses cannot be taken care of in online mode, it is presently high an ideal opportunity to comprehend that virtual science labs are genuine, they are possible, moderate and simultaneously they can offer different apparatuses for learning through far off access and experimentation. Virtual labs are perhaps the best methods of viably showing inquisitive understudies by permitting them to perform tests themselves for all intents and purposes instead of essentially being eyewitnesses. This move from active labs to virtual labs would without a doubt set aside cash and improve instructors' instructing proficiency. Moreover, it is exceptionally expected that encouraging methods ought to consistently be contemporary and tough enough to stay aware of arising present-day innovations, which can be best cultivated in India by building virtual labs in most instructive foundations soon and adequately interfacing them with continuous e-learning frameworks and MOOCs like Swayam, NPTEL, and others. Every one of these activities, I trust, will most likely assist India become an information and knowledge superpower in not-so-distant future.

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