
A MODERN APPROACH TO TRAIN BIOSCIENCE TEACHERS IN BIOTECHNOLOGY AT SECONDARY LEVEL

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ABSTRACT :

Bioscience teacher education has been considered very systematic as well as challenging stream of whole system of education with respect to its unique training on observation, experimentation, tools, techniques and exploring the facts of nature. Demand of bio science teacher education has been increased to produce such science teacher who could teach science not only effectively having sufficient pedagogical competency but also having enough knowledge in modern as well as latest science and technology content relevant to secondary school level. In recent days Biotechnology has been considered as one of the important course content in secondary school education due to its vast demand in industry, agriculture, medicine, research fields as well as for its popular vocational value. The paper discusses need, significance and status of Biotechnology at school education at national as well international scenario and presented the modes and strategies to impart Biotechnology in Bioscience Teacher Training by setting objectives to design theoretical, practical, and pedagogical courses with several suggestions. Further it discusses the challenges existing to achieve the goal and objectives to adopt this modern approach in bioscience teacher education and concluded the paper by highlighting the role of the present education system to accept this modern approach to educate bioscience teacher.

Keywords : Biotechnology, Teacher Education.

INTRODUCTION :

Teacher Education is one of the demanding fields in recent days due to its well accepted significance for the whole education system and its relation with in school education of the nation. As teachers play role of imparting education to the future citizens of the nation, their training quality holds the worth responsibility of constructing the not only society as well as the country but also for the all human civilization at all

via maintaining the quality of school education. Teacher education enable teachers to learn, practice, impart content knowledge as well as utilize the skills and competencies in an appropriate manner. Quality of teacher education can not be considered appropriate until and unless adopting modern prospective in its course curriculum as well as training, modes and experience.

In this context, science teacher education has been considered very systematic as well as challenging stream of teacher education field. Science teacher education is different stream of teacher education with respect to unique training on observation, exploration, experimentation, tools and techniques. As new concepts, scientific innovations, research findings are influencing the science curriculum frequently, what was taught in secondary classes twenty year back have been modified as well replaced by new scientific concept. Demand of acquiring novel scientific knowledge as well as selecting vocational courses have been realized in secondary schools due to future career opportunities in science as well for applying the skills at work place. Therefore challenges in science teacher education have been increased to produce such science teacher who could teach science not only effectively having sufficient pedagogical competency but also having enough knowledge in modern as well as latest knowledge in science and technology content relevant to secondary school level. In recent days Biotechnology has been considered as one of the important course content in secondary school education due to its vast demand in industry, agriculture, medicine, research fields as well as for its popular vocational value. Therefore Secondary schools in country are providing concepts and principles of Biotechnology at secondary level to make students familiar with this modern field of applied science.

Though Biotechnology education has been imparted from school level to college as well university level in the country in bioscience it is extremely harassing as well as unfortunate that teacher education system not taking strong steps to provide training courses related to biotechnology for bioscience teachers in several teacher education institutions. Some premier institutions are confused about need of Biotechnology in bioscience teacher education as well few are not considering biotechnology as a school subject at all in India!!! For example they prefer Teacher educator having M.Sc. Zoology /Botany qualification more as comparison to candidate having Life Science / Biotechnology. Here question may arise if person having M.Sc. Zoology can teach teachers about botany as well Biotechnology in teacher education institutions then why not person having M.Sc. Biotechnology can teach Zoology / Botany at the same place? It means teacher education institutions are not ready to merge new innovations as well experts of biotechnology in their course though school education(e.g.KVS /

NVS) are appointing Teachers having specialization in Biotechnology. Then who will train these Biotechnology teachers? It indicates Teacher education institution's traditional view to school education and ignorance to new knowledge in science. This is also against the Kothari Commissions (1964-66) recommendations i.e. "Isolation of teacher's college with universities, schools and teacher's college themselves should be removed". However some apex organizations suggest through their several publications, papers, frameworks teachers should be acquainted with latest technology in the field of bioscience in school education in one side as well as ignoring the experts, curriculum in Biotechnology in another side which clearly magnify the lacuna in our teacher education system. It is most surprising that although all are aware of importance of applied science and suggesting for modernization of science teacher education through implementation of training programme related to latest knowledge, technology in science no remarkable steps have been taken. The suggestions are only documented having no practical application. Contrary to our education system in foreign countries teachers are well trained in latest techniques. The present paper intends to find out the recent status of Biotechnology in school education and suggest strategies to science teacher education system to organize several training programs related to Biotechnology relevant to secondary level.

GOALS AND OBJECTIVES :

The main goal of this paper is to discuss the significance and status of Biotechnology in school education as well as explore modes and strategies to develop some training program related to Biotechnology for Secondary school Bioscience teachers. The objectives of this paper are:

- To discuss about the need and strategy to design some theoretical training program on Biotechnology for Bioscience Teachers working in secondary school.
- To discuss about the need and design some practical training program on Biotechnology for Bioscience Teachers working in secondary school.
- To discuss about the need and design some pedagogical training program for Bioscience Teachers teaching Biotechnology at secondary school

SIGNIFICANCE OF BIOTECHNOLOGY IN SCHOOL EDUCATION :

These days Science and Technology in school education has attained an imperative and compulsory place because of its wide application in daily life as well as for providing

vast scope to follow livelihood. Science is an active, energetic, broad field of knowledge and experience that made people to acquire suitable skills and competencies not only to adapt fast changing society in the whole course of innovations and modernization for a better living but also attempted to help world to resist the unfavorable change made in this process of transformation. According to Focus Paper on Science Education (2005) "Basically science is an open ended exploration. Its end results are not fixed in advance. Technology in other hand is also an exploration but usually a definite goal in mind" Biotechnology being an emerging field of applied science has been realized as boon to human resources for the satisfaction of unlimited needs and demands exerted in the present and future prospective of human civilization. It has already been deeply incorporated to day-to-day life of individual through its wide application in most of the dimension of way of living. This technology is growing its fullest to serve the basic purposes and became successful in occupying an exceptional position in present world view. It is beyond doubt that the role of Biotechnology in the progress of social, environmental as well as prosperity of this new age is worth mentioning.

Taking into consideration of challenge of rapid qualitative and quantitative growth in the field of agriculture, industry, environment and medicine, initiatives are being started to adopt Biotechnological strategies to ensure better productivity and economic progress in nation. As a result, the current trends in India suggested for bringing dynamic functions and expose above fields with novel and innovative techniques of Biotechnology to attain the goal of national development. To meet this revolutionary change Government of India established a separate Department of Biotechnology (DBT) in 1986, under Ministry of Science and Technology that committed to endeavor and extend remarkable progress through stating the vision for attaining new height in biotechnology research, setting biotechnology as premier precision tool of the future for creation of wealth and ensuring social justice - specially for the welfare of the poor. It has not only emphasized on sustainable development in research in every possible field of biotechnology and utilizing them for advantage humanity but also to build scientific and technological empowerment of India's incomparable human resource. Consequently, Biotechnology is in a phase of flourishing due to help of several efforts made by joint venture of both Government and private agencies.

In spite of several attempts, till now we are lagging behind in propagating biotechnology up to its maximum level as comparison to foreign countries. People of our country till not aware of basic fundamental information regarding this innovative technique where as in aboard it is recognized as a well-accepted popular tool to extract maximum benefits from different resources for humankind. Country like USA, UK,

and Australia are not only sufficient with latest research in this field but also adopted school education as a mean to penetrate its elementary facts to society. Thus, to make biotechnology conventional, there is a need of making students conscious about general aspects of biotechnology right from school level.

In India, education of Biotechnology at school level is imparted at higher secondary standard. NCF-2005 emphasized preparation of students for vocational streams at this stage. According to NCF-2005, "The courses offered at the +2 stage need to be alive to recent and current developments in the disciplines, as new knowledge areas are covered out, disciplinary boundaries shift and multidisciplinary studies develops". From a pedagogical and from a didactical point of view school education must deal with the basic knowledge as well as with the effects of Biotechnology. In addition its aim should be to improve the students ability of reasoned decision making in respect to this technological field. Education should lead the students to a basic understanding of the methods, the achievements and the effects of biotechnology on the one hand. On the other hand on the basis of this knowledge it should help the students to find own, justified decisions in respect to this topic and to act in a corresponding way. As the knowledge in the life - sciences has exploded during the last two decades, for science teachers it is necessary to restrict to the main fields of biotechnology for teaching. However, the central application fields of biotechnology (pharmaceutical industry, medicine, farming, nutrition and environmental technology) as well as the procedures (i.e. genetic engineering, cell culture techniques, cultivation of microorganisms) should be taken into account. Out of the variety of all the procedures that are summarized under the term biotechnology genetic engineering is still one of the most discussed. Especially because of its potential significance for the future in the following the examples for teaching biotechnology will focus on this technique (Harms 2002).

Realizing the current needs and demands, for this purpose chapters of Biotechnology are integrated in Biology subject in CBSE and state boards of our country at higher secondary level. It has aimed to introduce relevant concepts of Biotechnology to make students aware about this innovative technology as well as to motivate them to pursue career in this area.

Owing to the significance of Biotechnology education, the secondary school curriculum has included concepts like Principle of Biotechnology, Tools of Recombinant DNA Technology, Processes of Recombinant Technology, Cloning, PCR, Biotechnological Application in Agriculture, Genetically Modified Organism (GMO), Biotechnological Application in Medicine, Gene Therapy, Transgenic Animals, and

Ethical Issues related to this technology, Biopiracy etc. These concepts are enough to constitute and impart the primary idea regarding this novel technology that is necessary for present scenario. In addition to this several practical experiments related to this are also included in school.

However in foreign countries biotechnology education has been provided from elementary level. According to Harms (2002) "Already in elementary school traditional biotechnical methods can be dealt with, given that there is a relationship to the everyday life of the students, i.e. the application of biotechnology in food production. By carrying out experiments with microorganisms students make the experience that these creatures play an important role in food production, and they learn to look onto microorganisms in a differentiated way. In addition the meaning of fungi, bacteria and of other small organisms for decomposition can be shown by investigations of compost. On middle school level biotechnological processes can be integrated into the topics "ecology" and the education in environmental problems, i.e. in the meaning of microorganisms as reducers in the nitrogen cycle. In the context of health education bacteria, funghi and viruses are dealt with as pathogens that cause infections. When talking about human physiology with about 15 year-old students, enzymes and enzyme technology can be picked out as a central theme. By easy experiments, i.e. the degradation of pectin in the context of juice production, a connection can be made to economically important fields of Biotechnology. On this school level also the topic breeding - especially modern ways of cultivation - can be a linked to Biotechnology. On high school level the students ought to deal not only with applications of biotechnology but as well with the historical development of biotechnological knowledge. They are to know the main methods used in biotechnology and they must learn to judge in a reasoned way the (very often) ambivalent application possibilities of this technique. This means that ethical and social aspects of the complex topic biotechnology must be integrated in the science classes." Todt and Götz, 1998 conducted an empirical study in which they captured students interest in and attitudes towards biotechnology and gene technology in particular. In this quantitative study they used questionnaires. The results showed that the interest of students in genetic engineering develops at an age of about 16. Girls of this age are more interested in social and ethical aspects of the topic, boys' interest, however, is directed towards economical and technical aspects.

Table- 1. Examples for biotechnological experiments in the classroom (Bayrhuber and Lucius, 1992)

School level	Example
Elementary school	Production of yoghurt and sauerkraut.
Middle school	Experiments with and microscopical investigations of yeast and yeast dough. Gradual formation of lactic acid in sour dough. From juice to wine, from wine to acid.
High school	Enzyme-Linked-Immunosorbent Assay – detection of the Pelargoium Flower Break Virus in Pelargonium leaves. Hydrolysis of ? -DNA by restriction enzymes and separation of the DNA-fragments by gel electrophoresis. Production of citric acid. Comparative protein analysis.

Several investigations in Europe show that citizens are very critic whether their governments and other public committees can cope with the risks of biotechnological applications (Eurobarometer, 1993; Bauer et al. 1997). As a reason for this finding a lack of sound information of the public is seen. As a reaction to this results in several countries of the European Union the topic "Biotechnology" has been integrated into the school curricula. This fact led - among others - to a project called EIBE (European Initiative for Biotechnology Education) that was financed by the European Commission. The aim of EIBE is the information of the public - and of school students in particular - on Biotechnology (Grainger, 1996). About 25 teaching units on different biotechnology topics were developed by international groups. These materials information for teachers, students and parents as hints for literature etc. are combined in a multidisciplinary approach. Not only the scientific but also the legal and economic questions related to biotechnology are treated in the materials. Examples of the materials developed by the EIBE-Family are shown in Table 2. (Grainger 2002)

Microbes and Molecules	Transgenic Plants I + II
DNA Fingerprinting	Transgenic Animals
Biscuits and Biotechnology	A Model European Council
Issues in Human Genetics	Our Food
Fermentation Technology	Human Genome Project
DNA Model	Biotechnology and the 3rd World War
Debate of a Personal Dilemma	Environmental Biotechnology
Practical Immunology	The EIBE-Family

Table -2. Examples for units developed by the European Initiative for Biotechnology Education (EIBE)

MODES AND STRATEGIES TO IMPART BIOTECHNOLOGY IN BIOSCIENCE TEACHER TRAINING :

As teacher education is imparted through two types of students: Pre service Teacher education and In-service Teacher education for implementing Biotechnology education in Bioscience teacher training programme can be design keeping in mind the needs, requirements of both teachers in service as well student teachers. Training program for science teacher an be imparted by including several theoretical concepts, practical experiments as well pedagogical training programs for both student teachers as well in-service school science teacher.

Table- 1 Mode of Imparting Pre- service and in - service Teacher Training Program for Biotechnology.

SL.No.	Strategy	Concepts	Mode for Pre service Teacher	Mode for In service Teacher
1	<i>Content Knowledge Training Program</i>	Basic Principles, concepts in Biotechnology, Tools, Techniques, Application	<ul style="list-style-type: none"> ▪ Theory Class ▪ Project ▪ Discussion ▪ Group Learning ▪ Guest Lecture 	<ul style="list-style-type: none"> ▪ Seminar ▪ Panel Discussion ▪ Paper Presentation ▪ Workshop ▪ ICT ▪ Distance Learning ▪ Summer Course ▪ Guest Lecture ▪ Refresher Course ▪ Orientation Course
2	<i>Practical Training Program</i>	<ul style="list-style-type: none"> ▪ Electrophoresis ▪ PCR ▪ Tissue Culture ▪ Microbial Culture ▪ Immunology ▪ Biochemistry 	<ul style="list-style-type: none"> ▪ Use of ICT ▪ Websites ▪ CD ▪ Visit to Research Institution ▪ Laboratory Practical Class 	<ul style="list-style-type: none"> ▪ Use of ICT ▪ Websites ▪ CD ▪ Visit to Research Institution ▪ Laboratory Practical Class ▪ Teleconferencing ▪ Workshop ▪ Research Project ▪ Practical Refresher classes

3	<i>Pedagogical Training Program</i>	<ul style="list-style-type: none"> ▪ Lesson Planning ▪ Skill of Introducing Biotechnological Concepts ▪ Skill of Presenting them ▪ Skill of Using Teaching Aid ▪ Skill of Illustration ▪ Skill of Evaluation 	<ul style="list-style-type: none"> ▪ Practice Teaching Class ▪ Micro Teaching ▪ Role Playing ▪ Observation of Expert's Teaching 	<ul style="list-style-type: none"> ▪ Seminar ▪ Expert's Lecture Program ▪ Teleconferencing ▪ Workshop ▪ Observation of Expert's Teaching ▪ Refresher Course ▪ Orientation Course
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● ***Theoretical training program on Biotechnology for Bioscience Teachers working in secondary school :***

Experts can formulate as well introduce several concepts as well principles related to Biotechnology relevant to Secondary school students curriculum in teacher education institutions pre service as well in service science teachers. The basic ideas related to this science can be imparted through the several theoretical classes taken by experts. They can introduce the current topics as well as can solve their doubts related to various concepts in Biotechnology. In addition to this they can suggest as well discuss various activities related to Biotechnology.

Experts can introduce and discuss following concepts to both in-service as well pre service teacher to acquaint them with latest knowledge in Biological Science that needs systematic application of techniques to discover the facts. Here one can argue why to learn Biotechnology as Botany as well Zoology can provide such facts? The answer is the student teacher must have basic minimum knowledge on techniques that helps to explore the unknown latent facts of biological world. To make the knowledge horizon of bioscience teacher broader as well to have a clear outlook to prove the assumptions before school students and to present facts in the classroom in fast technical way it is necessary not to overlook Biotechnology in a secondary school Bioscience class. As today several techniques of biotechnology are applied in various field of Biological Science. If we are teaching school Students Science and Technology at secondary level then why not train about some technology in Bioscience Teacher Education Program in a modern way. The following theoretical concepts can be discussed in a teacher education classroom and can be included in Bioscience Teacher Education Program. History of Biotechnology, Principle of Biotechnology, Tools of Recombinant DNA Technology, Processes of Recombinant Technology, Cloning, PCR,

Biotechnological Application in Agriculture, Genetically Modified Organism (GMO), Biotechnological Application in Medicine, Gene Therapy, Environmental Biotechnology, Microbial Biotechnology, Fermentation Technology, Industrial Application of Biotechnology, Transgenic Animals, and Ethical Issues related to this technology, Biopiracy etc.

● ***Practical Training Program on Biotechnology :***

Teacher training institution can organize several practical programs related to Biotechnology. Teachers can be demonstrated with several practical experiments relevant to school level with equipments, materials. For this purpose several practical classes, workshops can be organized by the experts. As some practical experiments in Biotechnology need expensive apparatus as well as competent faculty members, in this case teacher educator can take the help of ICT to train teachers. Animated software, Internet, movie can be utilized to present the rationale, problem. Principle, theory, apparatus/chemical required as well as procedure of experiment in a modern way. Need assessment program can be organize to find the difficulty of teacher followed by discussion. It will help the Bioscience teacher educator to design their practical program.

Practical Experiments such as Electrophoresis, Polymerase Chain Reaction (PCR), Cloning, Steps of Recombinant DNA Technology, Immunology, Process of Tissue Culture, Microbial Culture, Biochemical Analysis of Genetic Material, Microbial Genetics, Procedure for making Transgenic Animal and Plants, Molecular Biology, Procedure of Gene Therapy, Process of Fermentation, Bioreactor, can be effectively demonstrated manually as well as through ICT to the teachers. These experiments are not only making teachers aware of techniques used in biological science but also prepare them to justify the facts of science before school students effectively.

As some of the experiment can not be conducted in the institution as it needs well equipped laboratory as well instruments and appropriate supervision of experts in that case visit to Research Laboratory and Observation of the laboratory as well as experiments can be organized. In addition to this use of Virtual Field Trips, Animations, Websites, Journal Reference Book, Teleconferencing with experts can be organized. Teachers can be assigned with several projects related to practical aspects of Biotechnology with special reference to secondary school education.

● ***Pedagogical Training Program on Biotechnology for Bioscience Teacher***

The bioscience teacher must be enough competent to teach biotechnological concepts adequately in the classroom. It demands teacher training on how to teach

these concepts systematically and interestingly. The teacher should teach these concepts in such a manner that students could understand them with ease. Teachers have to go beyond the text book as well relate these concepts with their daily life. Pedagogical training program would enable them to teach these difficult concepts in a simple and flexible manner.

For this purpose teachers can be assigned to prepare some lesson plans related to Biotechnology. Teaching of Biotechnology can be demonstrated in the bioscience teacher education class by the experts. Several Microteaching class, Role playing, observation classes can be organized. Skill of introducing, presenting, using teaching aids, illustration, evaluation biotechnological lessons can be emphasized in the class. For example for introducing teacher can be suggested to give example of Spider Man Movie where recombination of man and spider gene has been shown and produced recombinant organism. For presenting the lesson use of ICT, software programs can be recommended. Use of constructivist approach as well as methods such as demonstration cum discussion, discovery, problem solving and cooperative, collaborative, and project methods can be suggested to the teachers. In addition to this preparation and use of models, charts, projected, non - projected, as well as innovative teaching aids related to biotechnological concepts can be discussed in pedagogical training program for bioscience teacher. Use of several programs telecasted in TV, Radio and way to utilize them in bioscience classroom can be explained. For developing illustration skill of teacher educator can discuss with teachers about several day to day application of biotechnology in pupil's life. For example school students are taking food such as bread, butter, pickle, preserved food materials available in market which are also processed by biotechnological principles. Teacher can use science fiction movies, cartoon programs, Virtual field trips for illustrating complex and new concepts of Biotechnology. All these innovative ideas can be discussed in the teacher education classroom. For the evaluation purpose teachers can be suggested to use project, co curricular activities, and assignments to evaluate students learning biotechnology at secondary level. Projects such as: constructing models on Recombinant Technology. PCR, Bioreactor can be discussed by the bioscience teacher educator. Co curricular activities related such as seminar, group discussion can recommended evaluating school students. Assignment such as collecting information on transgenic animal, plants, Application of Biotechnology in Agriculture, Industry, Medicines and their design can be developed by the teachers in bioscience teacher education classes.

CHALLENGES :

To implement these modern approach teacher education institutions may face following challenges:

- Development of pedagogical courses as well as practical courses related to Biotechnology in Bioscience Teacher Education
- Changing the attitude of educational planners, administrators for giving importance to Biotechnology as other traditional subjects in school education.
- Effective Execution of Bioscience teacher training program on Biotechnology relevant to current school education.
- Appointment of Experts having specialization in Biotechnology as well as Education.

CONCLUSION :

To make bioscience education more active, up to date as well to acquaint with latest technology need of Biotechnology education in teacher education institutions is seriously in demand. Because with out the theoretical, practical, pedagogical knowledge of Biotechnology, bioscience teacher can not propagate as well teach school students effectively. It is beyond doubt that Biotechnology in Bioscience education can be considered as a modern approach to train secondary school bioscience teacher that not only helps and inspires school students to learn Bioscience effectively via their effective content knowledge and pedagogical competency but also make Biotechnology popular in our country for bringing further prosperity through industrial, economical, agricultural, environmental as well medicinal evolution.

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