ANALYSIS OF IN-SERVICE AND PRE-SERVICE TEACHERS' UNDERSTANDING OF SOME CONCEPTS OF BIOTECHNOLOGY IN BIOLOGY CURRICULUM

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The emergence of multidisciplinary approaches has always benefited science with newer discoveries. Biotechnology which has tremendous applications with many possibilities should be introduced to students efficiently for their better vision of the subject. The purpose of this study is to analyse the in-service and pre-service teachers about their awareness regarding the latest additions in the field of biotechnology. In order to assess, a questionnaire was developed and the responses from both categories were thoroughly analysed with descriptive statistics. It was observed that the pre-service teachers have a better understanding of the biotechnological concepts than those in-service teachers. Considering the fact that pre-service teachers are in their studying phase, it is interpreted that this category of teachers is trained with an updated syllabus compared to the other. This might be an addition that helps them to be updated. The in-service teachers having good exposure to the older syllabus lack awareness regarding topics from the latest Biotechnological applications. Poor capacity-building programmes and fewer chances for proper up-gradation are some of the barriers for the teachers who are already in service. The addition of biotechnological concepts in the syllabus and improved capacity-building programmes might help to improve the awareness of the pre-service and in-service teachers, respectively.

Keywords: In-service teachers, Pre-service teachers, Fermentation Technology.

Introduction

Every new concept imbibes into a child with the emergence of new neuron activity patterns (Uddin, et al., 2020). The way of teaching-learning plays an important role in the amount of excitement towards any subject that students possess. The process of science learning inculcates ideas clearly and makes them capable of thinking innovatively. Classical biology is the root of every modern branch emerged in the area of biology to date. The discovery of Gregor Mendel, an Austrian monk, helped biology to attain its importance at par with chemistry and physics. The irreplaceable work of Mendel by discovering the genetic concepts finally helped biologists to find the cause-and-effect relationship along with quantifying observations. Finding new chains of linking biology was a spark between the holistic and reductionist approaches (Kellenberger, E., 2004).

The integration of multidisciplinary and holistic education across science and other subjects ensures unity and collaboration (Schumacher, et al., 2016; Bensaude-vincent., 2016; National Research Council,US 2009). This leads to the emergence of different streams in biology including molecular biology, cell biology, microbiology, biochemistry, bioengineering, biomedical engineering, biomanufacturing, molecular engineering, bioinformatics, etc. (Sadiku, et al., 2018). Technological mammoth such as bioprocessing, tissue culture plays an inevitable role in the production of secondary metabolites, alcoholic beverages, single-cell protein, and antibiotics, etc. at an industrial scale. Education policy has stated that there are three fundamental elements that affect the educational system; they are teacher, student, and educational environment. Teachers being an important component of the teaching-learning process, their continuous professional development play a crucial role in the improvement of students' academic comprehension and their learning environment as well.

As we discussed the importance of teachers in the educational system, the in-service teachers who had accomplished their education erstwhile, but may not keep themselves abreast with new researches and fast development of biology appear as its applications under biotechnology. Due to the dynamic nature of biology and numerous ongoing research activities, the rapid advancement of the field is huge, but the deprivation of their current knowledge creates a gap in academic comprehension.

On the other hand, pre-service teachers are in their learning phase mastering their skills according to the given curriculum. Pre-service teachers are also responsible for higher secondary teaching often after their completion of postgraduate degree, which might create chaos in their own academic discourse while classroom teaching as a teacher. Moreover, syllabus of pre-service teacher education programme includes these concepts of biotechnology in their biology curriculum at the undergraduate level.

There is a need for continuous improvement in the teacher development programme and professional education which was helpful for an individual to become an effective teacher (Reynard, 1963). Research depicts that several efforts had been made for capacity building of in-service teachers similar to pre-service teachers by using various approaches. This helped the teachers to fill the gap of understanding about the subject in elementary education (Weaver, 1965). Several other studies also concluded that there is a need for improving in-service capacity building programs in the education system (Wynn, et. al., 1961). In 1959 Gerheim and Cory found that teachers were cooperative and they valued the implementation of the in-service capacity building programme conducted for their professional development (Gerheim, 1959 and Cory, 1959). Different workshops, discussions, and conferences were also conducted for the betterment of the programme (Willink, 1959). Studies also indicate that a system-based change in the pre-service teacher education programme will be beneficial for developing a leadership capacity in order to sustain the education system (Ferreira, J.A., et al., 2015).

On the basis of the findings concluded through different studies, there is a need to know about the understanding of in-service and pre-service teachers in the newly introduced area. So, along with traditional biological aspects which serve as the fundamental pillar, the importance of the newly introduced area of biology which has a huge technical possibility should also be conveyed to learners effectively. For this purpose, we have selected areas related to fermentation technology and plant tissue culture for assessment as the major topic since their applications are highly exploited at the industrial level.

Thus, the present study was carried out keeping in view the following research questions:

1. Do the in-service post graduate teachers understand the concepts of biotechnology in biology curriculum at the senior secondary level?
2. Do the pre-service teachers understand the concepts of biotechnology in their biology curriculum?
3. What are the gaps for need-based capacity building programme for in-service post-graduate teachers in subject biology?
4. What are the recommendations for improving biology curriculum for pre-service teacher education programme?

Objectives

Realising the current needs and facts described previously, further research on biotechnology education is necessary. The major aim of this study is to identify the gaps for curricular inputs and designing the need-based capacity building programmes for the pre-service and in-service teachers, respectively. Effective changes might enhance the vision and aura of teachers and thereby helping in better implementation of the subject in school education.

The study was carried out considering the following specific objectives:

- To assess the in-service post graduate teachers' understanding of new areas of biotechnology in biology curriculum at the senior secondary level
- To assess pre-service teachers' understanding of concepts of biotechnology in their biology curriculum
- To provide suggestions for need-based capacity building programme for in-service post-graduate teachers in biology subject
- To provide recommendations for biology curriculum for preservice teacher education programme

Research Methodology

Theoretical framework

Biotechnology concepts in biology curriculum has a specific standing related to teachers' content knowledge (CK) because of its multidisciplinary and interdisciplinary nature (Bensaude-Vincent, 2016) and applied aspects combined to it provides solution to societal problems (Kleiman, 2009). Learning of biotechnological concepts always built upon the basic biological concepts (Falk, et al., 2008) and develop problem solving competency among learners of biology (Fatmawati, 2016). Moreover, there is more influx of information through various information sources making the biotechnological concepts more familiar (Kirkpatrick, et al., 2002) in which students may have more curiosity in the classroom. Content knowledge is an essential part of teacher's professional knowledge (Rogers, et. al., 2007; Baumert, et al., 2010). There is general unanimity that CK is very much required, however it is not sufficient for efficient teaching-learning process (Rogers, M.P. et. al., 2007).

Researchers all over the world have assessed CK of teachers using various methodologies.

One of the most common methods was attempted to directly measure CK using tests, consisting of right/wrong and/or multiple-choice items (e.g., Jeffrey Hill, et al., 2008). There are researches on the teachers' misconceptions regarding subject content knowledge which have influenced learning outcomes of students (Krauss, et al., 2008).

There is little or no mention of theoretical frameworks in the literature regarding assessing the understanding the concepts of biotechnology in the current curriculum of biology among in-service teachers teaching biology or among pre-service teachers in their biology curriculum. To assess the understanding of newly incorporated biotechnology concepts by in-service teachers teaching biology and pre-service teachers in their biology curriculum require an appropriate measuring technique for accurate data collection and arriving at correct and error free conclusions for meeting out the objectives of the study. Construction of an appropriate instrument for assessing deep-seated understanding of theory as well as the practical part of the concepts is a prerequisite. So that recommendations may be made for designing need-based capacity building programme for in-service teachers. Besides, recommendations may be provided for curriculum improvement in teacher development courses.

Since any instrument for such studies was not reported earlier it is appropriate to develop a tool afresh including items that assess understanding and process skills of the concepts of biotechnology. Thus, a thorough literature survey was carried out and similar studies in other fields were followed to maintain compatibility with other PCK assessment instruments (König, et al., 2011; Rohaan, et al., 2009; Schmelzing, et al., 2013). In the present study we have considered assessment of knowledge component only that included items assessing content, methods and skills in biotechnology.

Tool development

Keeping in view the specific objectives assessment tools included items that can assess the understanding of in-service and pre-service teachers in the following concepts which are a part of the present curriculum of biology:

1. Plant tissue culture technology (PTCT)
2. Fermentation technology (FT)
3. Applications of PTCT and FT

Items of the questionnaire were covered to assess the understanding of theoretical aspects, practical and technological skills and terminology recognition and differences and deep-seated understanding of concepts.

Items were subjected to expert validation and field try-out and finalised.

Research Design

The present study was completed using survey method in which a questionnaire after expert validation and field try-out was administered among in-service and pre-service teachers.

Participants

Two categories of participants were identified as respondents of the questionnaire:

(i) In-service teachers from different school set-ups including Post Graduate Teachers of KVS, NVS, state government school teachers and private school teachers teaching biology

(ii) Pupil teachers of integrated B.Sc. B.Ed. professional development courses. Only biological science students were a part of the study.

Sampling Techniques

Sample of the present study was drawn by using purposive sampling technique. In-service teachers attending capacity building programmes or refresher courses were a part of the study. Some of the in-service teachers from private schools of Ajmer (Rajasthan) were also respondents. Fourth year Pre-service teachers of integrated B.Sc B.Ed course with biological science background were also a part of the sample.

Data Analysis

Analysis of the data was carried out using descriptive analysis by calculating percentage, mean, standard deviation, standard error of mean as well as t-test analysis. We utilised the Origin 2021b programme for this.

Results and discussion

The participants' responses to questionnaire were examined and presented in Table 1. Table 1 reveals that the responses of in-service and pre-service teachers recorded for the items 1 to 25 shows diversity in marking their answers.

Results illustrated in Table 1 reveals that pre-service teachers perform better in terms of pure cell culture and air lift fermenter concepts with respect to the other group. However, the findings from the analysis were unsatisfactory for all respondents. Topics from developmental biology such as differentiation, de-differentiation and determination, as well as more advanced topics such as micropropagation, elicited very few positive responses from the two groups of teachers.

Table: 1 Responses for biotechnological aspects of in-service and pre-service teachers

S. No.	Items included in the questionnaire	In-service teachers Sample Size (74)		Pre-service teachers Sample Size (114)	
		(+ve) Response	(-ve) Response	(+ve) Response	(-ve) Response
1	Recognise aseptic environment in tissue culture	56	18	104	10
2	Recognise technical requirement of aseptic transfer in tissue culture skills	60	14	102	12
3	Understand pure culture of a single organism in culture tube	12	59	19	95
4	Recognise callus	59	15	95	19
5	Aware of the terminology in vitro cultivation	66	8	109	5
6	Aware of the process of differentiation	60	14	80	34
7	Aware of the process of dedifferentiation	37	37	57	57
8	Aware of the process of determination	17	57	43	71
9	Recognise an explant	37	37	58	56

10	Recognise suspension culture	33	41	65	49
11	Understand application of plant tissue culture for haploid plant production	54	20	71	43
12	Recognise "de novo"	35	39	47	66
13	Recognise epicotyl	51	23	80	34
14	Understand the process of hardening	18	56	26	88
15	Understand the process of fermentation	21	53	21	93
16	Differentiate between plant growth regulators and hormones	34	40	33	81
17	Recognise enzymes	25	49	57	57
18	Recognise Hypocotyl	31	43	48	66
19	Understand mode of bioreactor operations and growth cycle of a cell culture	23	51	45	69
20	Understand growth cycle of a culture system	42	32	54	60
21	Understand mode of bioreactor operations and growth cycle of a cell culture	38	36	65	49
22	Recognise genetic or epigenetic variations	40	34	76	38
23	Recognise bioreactor design	9	65	27	87
24	Understand the process of downstream processing	28	46	32	82
25	Understand the parameters of bioreactor operations	40	34	80	34

When compared to other topics, moderate responses were seen while addressing the function of hormones in growth, the method of operation of the fermentation process

items concerning haploid plants, aeration, and agitation in reactors are better, which demonstrates that the teachers have been well exposed to these concepts of

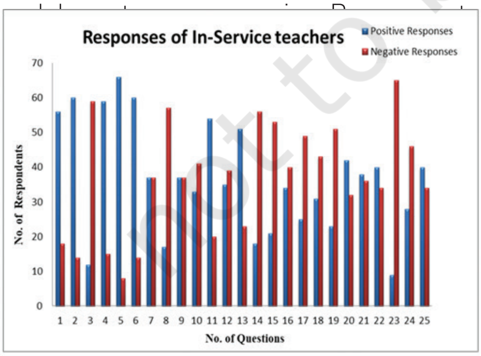

Fig. 1: In-service Teacher's Feedback

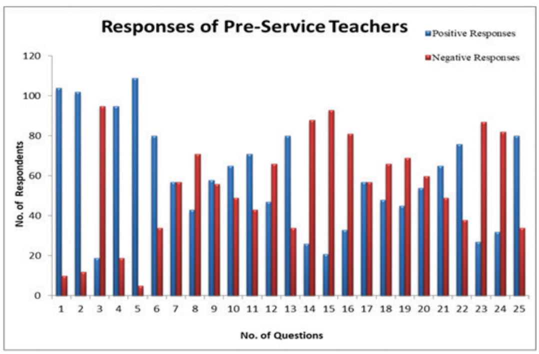

Fig. 2: Pre-service Teacher's Feedback

The least affirmative responses provided by the in-service teachers for assessment items 3, 14 and 23 were related to tissue culture techniques in biotechnology, Similarly, the number of positive responses to item number 9, 12 and 18 was also very less as depicted in Figure 1, which are related to understanding of biological terminology required not only for science communication but also required for other competencies. Also, their response for basic concepts of biology required for understanding the concepts of biotechnology for item 8 and 17 was also consistently less positive.

The lowest number of positive responses were provided for item 3 in the case of teacher trainees, demonstrating a considerable disparity between the two categories of teachers' positive response rates (Table 2).

Table –2 Percentage of Positive Responses of both the Groups

Q.NO.	In-service	Pre-service
1.	75	91
2.	81	89
3.	16	16
4.	79	83
5.	89	95
6.	81	70
7.	50	50
8.	22	37
9.	50	51
10.	44	57
11.	72	62
12.	47	41
13.	68	70
14.	24	22
15.	28	18
16.	45	28
17.	33	50
18.	41	42
19.	31	39
20.	56	47
21.	51	57
22.	54	66
23.	12	23
24.	37	28
25.	54	70

The findings may have significance for understanding that pre-service teachers know the curriculum more effectively than in-service teachers. While both groups provided accurate responses for item number three, in particular, in-service teachers had more affirmative responses than pre-service teachers for items 6, 11, 12, 14, 15, 16, 20, and 24. Although for all other questions pre-service teachers have somewhat more knowledge than in service teachers. The pie chart in Figures 3 (A and B) makes it very evident that pre-service teachers outperform as compared to In-service teachers in terms of favourable replies. Pre-service teachers answered more positive response to the items assessing cutting-edge technologies like plant biotechnology, bioreactors, fermentation technology, cell culture technology, and bioprocess engineering, but in-service teachers responded more to questions about the differentiation process, haploid plants, plant growth regulators, and downstream processing etc. In case de-differentiation, the responses recorded from both the groups were equal, i.e. 50 per cent.

The analysis of the data gathered also have shown that neither category understands how to cultivate a single organism in pure culture. Figure 4 represents the understanding of different biotechnological concepts such as growth and development, culture and regeneration, operational modes, designing of fermenter, bioreactor and downstream processing on the basis of percentage score of positive responses from pre-service and in-service teachers. In-service teachers have better clarity about growth and developments, culture and regeneration, operational modes and designing of reactor, even still, relatively few people responded favourably to

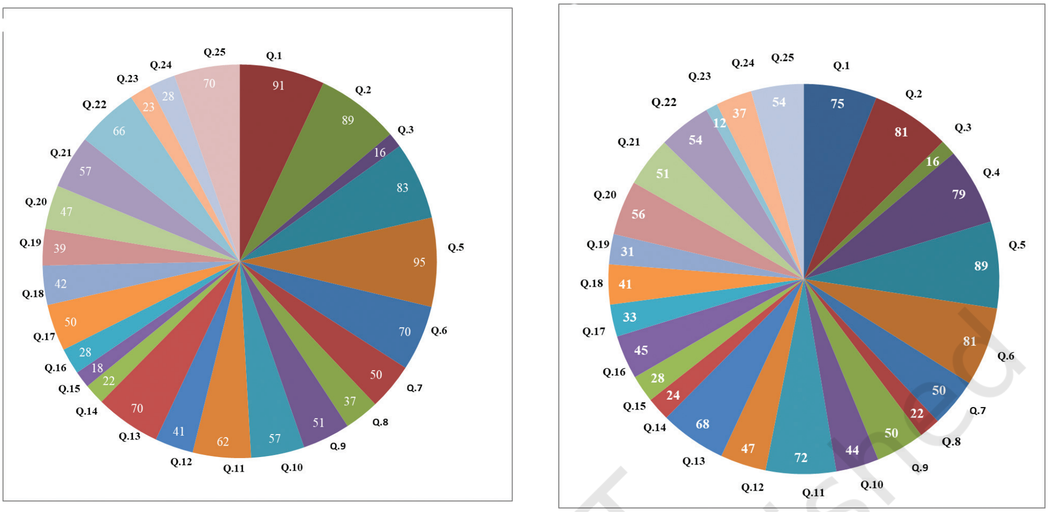

Fig. 3: Percentage of Positive Responses of (A) Pre-Service and (B) In-Service Teachers

inquiries about bioreactors and downstream processing. Thus, topics related to bioreactor and downstream processing with more focus on experimental and the other pedagogical along with assessment inputs should be more emphasized in the curriculum of pre-service teachers. On the other hand, in- service teachers have more understanding about culture and regeneration but least about growth and developments, operational modes, designing of reactor, bioreactor and downstream processing. Thus, these topics should be included while designing of capacity building programme for the in-service teachers which could help them to teach biotechnology efficiently.

It can be concluded from the results discussed above that the pre-service teachers had better understanding about the concepts than those of in-service teachers' group. It can be interpreted that since the pre-service teachers have an updated syllabus in their curriculum and considering the fact that they are still in the studying phase, they might have better access to the information sources that they can keep themselves updated regarding the new developments and researches in the area. In contrast, the in-service teachers have an exposure to an older syllabus which covers limited topics from biotechnology. The lack of chances to upgrade their vision about the newer addition in the field might also be a barrier for the teachers who are already in-service. And, this is the reason they are unable to keep themselves updated to the application-based booming field of biotechnology. They may or may not have access to information retrieval infrastructure where they are affiliated to. Besides, teachers are not in touch with the faculty of different national level institutions working in biological researches. Moreover, teachers working in schools at remote places utilise more time and energy in commuting.

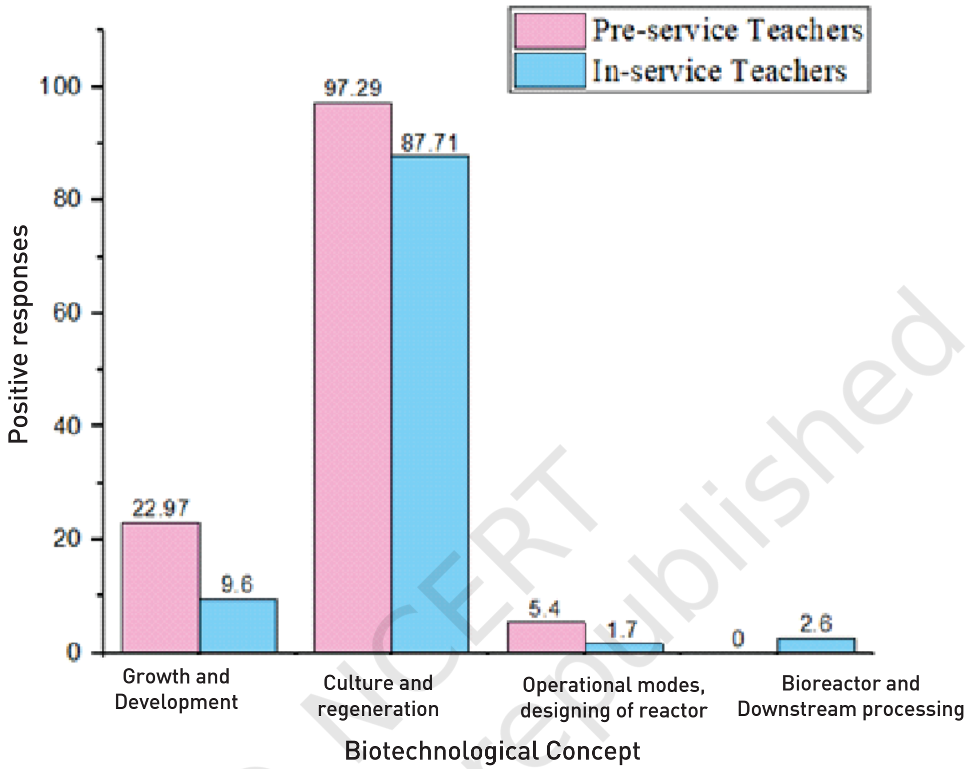

Fig. 4: Positive Responses of Teachers in Biotechnological Concept

Recommendations

In the light of current scenario, it is well understood that biotechnology is an applied evolution and technology integration in biology. Following are the recommendations in context of school education:

1. Advancement in many areas such as cloning, stem cell research, genetic engineering, CRISPR-Cas 9 gene editing tools, phylogenetic research etc; along with plant tissue culture and fermentation technology can be beneficial for both the students who are thinking to pursue their academic career in this area in their tertiary education. And, even if, they are not, it is important that the fundamentals of the same may be a part of biology curriculum in school education so that each and every citizen in India would have minimum literacy for biotechnological concepts because of their biology curriculum in school education.

2. On the basis of the results of the present study, it is recommended that there is a

need to upgrade the syllabus of the pre-service teacher's education programme by introducing recent and advanced biotechnological approaches as content weaved in with pedagogy and assessment to develop required competencies and to achieve learning outcomes.

3. Teachers should be able to focus on student's weaker section by employing different ICT tools like internet, interactive videos, animations, power points, virtual laboratory in teaching of biotechnological concepts, etc.

4. There is a need of hands-on sessions for each topic to improve the ability to perform experiments along with the theoretical clarity among learners.

5. Since concepts of biotechnology are applied aspects of traditional biology, they provide solutions to many contemporary problems. Teachers with enhanced aura with understanding of these biotechnological concepts may take their classroom process in a better shape to enhance students' problem-solving skills by providing hands-on biotechnology activity. Students develop better competencies for critical thinking, problem-solving skills and creativity skills by performing biotechnological experimentations (Pauwels, et al., 2001). Research studies also indicate that an outside hands-on intervention increase students' content knowledge as compared to students receiving biotechnology information in a traditional learning (Bigler and Hanegan, 2011).

6. In case of in-service teachers, there is a need to conduct capacity building programmes frequently which could improve their weaker section along with the introduction into the current advancement in the subject. Through improving the efficiency of both groups of teachers, we can strengthen the fundamentals of students through the existing biotechnological research and it could contribute to the future research directions also.

Future Prospects

The emergence of this study may be beneficial in suggesting an intervention framework for a capacity-building programme for in-service teachers and curricular input for pre-service teachers in the future, so further research in this area is ongoing.

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