

Teachers' beliefs and understanding about biotechnology and the effect on biotechnology education in Sri Lanka

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Abstract

This study examines teachers' understanding of the connections between key concepts of biotechnology and underlying biological principles and their effect on biotechnology education in school. Using a structured questionnaire (administered before and after a training course), we examined selected teachers' understanding of these relationships at school level in the Eastern Province in Sri Lanka. Most teachers believe that biotechnology education is important and that the interest about the subject and subject information contributes to this attitude. An intensive training course of teachers improved the quality of biotechnology teaching by enhancing interest about the subject of teachers at the Advance Level in the Eastern Province of Sri Lanka.

Keywords - biotechnology, knowledge, teaching, genetics, Sri Lanka

1. Introduction

Producing scientifically and technologically literate citizens has been a concern of educators and many policy makers around the world for more than three decades. UNESCO (1994) suggests that scientific and technological literacy are necessary to deal with the requirements of modern life. An emphasis on strengthening scientific literacy is evident in school curricula all over the world.

Over the past decade, policy recommendations in Sri Lanka have aimed at preparing a scientifically literate national work force which is equipped to compete in an increasingly science and technology-based global economy (Lumpe, Haney and Czerniak, 2000). In the recent curriculum revision, secondary science subjects underwent many changes. A variety of new aspects has been incorporated including addition of more biotechnological topics in Advanced Level (A-level; age 16–18) biology.,

Rapid development of biotechnology has contributed to important biomedical, agricultural and industrial innovations (Fonseca, Costa, Lencastre and Tavares, 2012). These innovations and their impact challenges the public by raising many controversial issues

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(Hanegan and Bigler, 2009). With increased media attention to litigations regarding issues and concerns associated with human cloning and the production of genetically modified (GM) organisms, schools and teachers are being urged to promote biotechnology education (Bryce and Gray, 2004; Hanegan and Bigler, 2009). As a result, in recent years, biotechnology-related topics have been incorporated into secondary science curricula in many countries (Hanegan and Bigler, 2009). Sri Lanka is no exception.

The role of the teacher, and their beliefs about teaching and the subject matter they teach, cannot be ignored if the revised curricula are expected to bring about change in the classroom (Lumpe et al., 2000). Teachers embrace a set of beliefs, practices, theories and craft knowledge that influences their approach to implementation of the curriculum (Keys, 2007).

Beliefs have been defined in a variety of ways. Oliver and Koballa (1992), as cited by Lumpe et al. (2000), stated that beliefs are often equated with knowledge, attitudes and idiosyncratic convictions, or they reflect a person's acceptance or rejection of a proposition. People are often confused in attempting to differentiate beliefs from other related concepts such as attitudes, values, judgements, and dispositions. Pajares (1992) argued that clusters of beliefs about a situation create attitudes, and attitudes become action agenda that influence decisions and behavior. In other words, people act upon what they believe. Bandura (1997) asserted that beliefs are the best indicators of the decisions people make throughout their lives.

Ample research evidence is available to support the view that teacher beliefs have direct impact on teacher's practices in the classroom. Beliefs influence the way the teacher decides his or her teaching objectives, lesson plans, approach towards students and the evaluation of learning in the classroom (Munby, 1982; Brickhouse, 1990; Pajares, 1992; Prawat, 1992; Richardson, 1996; Levitt, 2002). Teacher beliefs about students, learning, teaching and the nature of science influence teaching practices (Wallace and Kang, 2004). Researchers have shown that beliefs concerning their society play a key role in the way teachers interpret scientific knowledge and in turn teach it in classroom (Pajares, 1992). Purposefully designed questionnaires, interviews or careful and patient observation are necessary to explore the beliefs of teachers, which would in turn be helpful for the improvement of teaching and learning.

Since teachers' practice is influenced by content and pedagogical knowledge, as well as their beliefs related to the subject matter, it is essential to explore teachers' beliefs about biotechnology and biotechnology education (Falk, Brill and Yarden, 2008). Identifying these elements can help explain if and how teachers' engagement in biotechnology education is compromised by external influences such as cultural and social factors; and by the availability of equipment and other facilities in the teaching-learning environment.

2. Study Objective, Methodology and Tools

Study Objective

This study, conducted in the Eastern Province of Sri Lanka, examines the beliefs and attitudes of A-level biology teachers and other teachers, participants in an in-service course, about biotechnology and the effects on their biotechnology teaching. The investigation focused on teachers' receptivity to biotechnology education, aiming to identify the main constraints to their engagement in teaching biotechnology-related topics in a context of

resource limitations in the province. The questionnaire based study was done by using a quantitative assessment approach.

Sample of the Study

One hundred and twenty-five (125) school teachers from schools in the eastern province (Ampara, Batticaloa and Trincomalee districts) participated in the survey (101 females and 24 males). The participants were in-service secondary biology teachers who participated in a teaching workshop on biotechnology organized by the National Science and Technology Commission in association with the Provincial Department of Education, Eastern Province, Sri Lanka. Verbal consents were obtained from the participants by explaining the purpose of the study. Baseline data were collected before starting the workshop about knowledge and beliefs of the participants on biotechnology. After the two-week intensive training, the same questionnaire was administered and the collected data were analyzed.

A mixed group of advanced level (A/L) secondary teachers, biology teachers and teachers of other subjects, was considered eligible to participate in this survey because, even if all are not specialized in the field of biotechnology teaching, they as a peer group in the course went through the same pedagogy course and mutually influenced each other about beliefs and attitudes on teaching and learning. After the training, the teachers went back to their respective schools when the second set of data were collected. Eighty-two (females 65 and males 17) of the original 125 responded this time.

Research Instrument

A multi-dimensional questionnaire consisting of 23 questions (as shown in Appendix) was designed by adapting items from instruments prepared for studies conducted in different countries (Fonseca et al., 2012; Bryce and Gray, 2004). The content validity of the instrument was scrutinized by three A/L teachers with more than ten years' experience. The internal consistency of the instrument was assessed with the help of ten A/L teachers who attended a similar workshop in the North Central Province. Cronbach's alpha measure was applied to test internal validity of the instrument.

The first eight questions (see Appendix) of the questionnaire were to gather the socio-demographic data of the participants. Other questions were about teachers' beliefs about biotechnology intended to appraise the importance they attribute to it, their attitudes towards it, and their interest in it. A five-point Likert-type scales was used to differentiate the responses. In addition, a dichotomous question (Q22) was also included on attitudes.

Teachers' attitudes are highly complex and multi-dimensional, determined by the interaction of cognitive, affective and behavioral factors (Fonseca et al., 2012). The cognitive component of teachers' attitudes was judged by their response on the relationship of biotechnology to the quality of life. A question was asked to evaluate the teachers' interest in biotechnology (Q15).

Teachers' intention to buy Genetically Modified (GM) products or to get genetic tests for medical diagnostics was ascertained (Q16). This relates to behavior component of the respondents. Question 19 posed a dichotomous question to check if teachers think that GM foods are safe. This question evaluates the affective component of teachers' attitude.

The accuracy of teachers' knowledge and the quality of materials they provide to students are highly influenced by the selection of information sources by teachers (Duke and Ward, 2009). Therefore, questions 13 and 22 were intended to evaluate teachers' decision to use information sources according to their availability. Calderhead (1996) points out the relationship between beliefs and experience and states that teachers' past experiences influence the way they think about their work.

Data Collection and Analyses

The study was conducted between 14 to 28 February, 2017. A printed version of the questionnaire was developed and administered in the participants' first language. The original questionnaire was prepared in English and translated into Sinhala and Tamil. All three versions (English, Sinhala and Tamil) were identical in content. Sufficient time was given to the participants at the end of the workshop to complete the questionnaire.

The data collected were codified, recorded, cleansed and subjected to descriptive statistical analyses to evaluate their suitability for further examination. Missing values for certain items was estimated by linear interpolation as described by Twisk and de Vente (2002) and Henson and Roberts (2006).

The correlations between ordinal variables were evaluated using Spearman's rank correlation coefficient. The strength of the relationships was expressed based on the values described by De Vaus (2002) and cited in Fonseca et al. (2012, p372). The scores were considered low, moderate or large when the correlations were <0.30 , $0.30-0.50$ or >0.50 , respectively. All data analyses were carried out using the statistical package for the social science (SPSS) version 17.0.

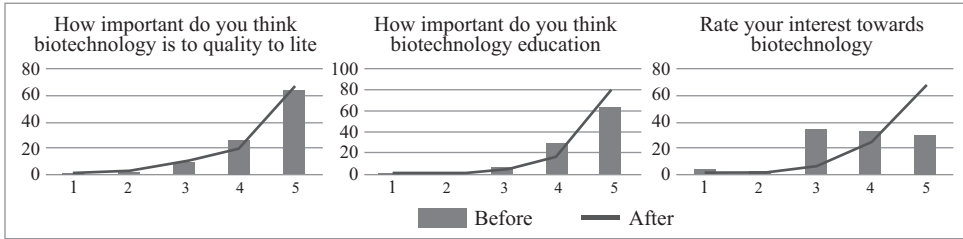
3. Results and Discussion

Teachers play a key role in the promotion of scientific literacy (Fonseca et al., 2012). Teachers' orientation toward specific subjects has an impact on their practice (Van Driel et al., 2007). As such, understanding teachers' beliefs is important to predict their practices and instructional decisions.

Teachers' belief about importance and relevance of biotechnology

There is a general belief that the application of biotechnology is important for improvement of the quality of life despite the controversy about some implications of this technology (Gaskell et al., 2006). The teachers surveyed in this study revealed that they believe in the importance and relevance of biotechnology for quality of life (Fig 1). This agrees with the conclusions of Fonseca et al. (2012). These results suggest that the biology teachers who participated in this study hold beliefs and attitudes similar to those of the public. A closer look at the salient features of teachers' cognitive and affective responses shows that they are positive about the importance of biotechnology for the improvement of the quality of life. Teachers' belief about the importance of biotechnology for quality of life and biotechnology education remained highly positive before and after the training course; however, their interest in biotechnology as a subject increased tremendously as a result of the in-service course (Fig 1).

Fig 1- Importance of Biotechnology towards Quality of Life, Education and Interest



Teachers’ perspective about biotechnology

It is important to acknowledge teachers’ beliefs when planning to improve or change their practice (Van Driel et al., 2007). Teachers’ beliefs about teaching, learning, curriculum objectives and the subject matter taught influence teaching outcomes (Gess-Newsome, 1999). Therefore, it is imperative to understand the teachers’ beliefs about biotechnology education and the factors that influence them. In the present study, most of the teachers considered biotechnology education to be very important. According to the teachers’ perspective, the importance of biotechnology education positively correlates with the importance of biotechnology to the quality of life and the interest towards biotechnology (Table 1). Nonetheless, this result must not be overestimated as these variables are moderately correlated with a coefficient of $r = 0.365$ (Table 1). Moreover, the importance of biotechnology positively correlates with the level of information that the teachers possess about biotechnology (Table 1). This indicates that when teachers become well-informed about biotechnology, their attitude towards considering the importance of biotechnology education changes in a positive way.

Table 1: Teachers’ Beliefs about Biotechnology, Biotechnology Education and their Interest towards Biotechnology

	Yes Before (%)	Yes Before (%)	Yes Before (%)	Yes Before (%)
Do you know what about biotechnology means (Q8)	23.2	100	76.8	0
Do you like to learn about biotechnology (Q9)	99.2	98.8	0.8	1.2
Do you know what Genetically Modified Foods (GMF) are? (Q16)	60.8	97.6	39.2	2.4
Would you eat GM food if it is freely available for you? (Q17)	19.2	70.7	80.8	29.3
Would you purchase GMF for your consumption?(Q18)	21.6	75.6	78.4	24.4
Do you think that GM food is safe to consume?(Q19)	12.8	62.2	87.2	37.8
Do you think that GM food can be a solution for world food shortage?(Q20)	68.0	92.7	32.0	7.3
Do you think that GM food can be a solution for malnutrition?(Q21)	37.6	82.9	62.4	17.1
Do think that there will be environmental issues by the cultivation of GM crops?(Q22)	66.4	61.0	33.6	39.0

How the training influenced the perspective of teachers about biotechnology towards a positive direction can be seen in the following expressions about the importance and relevance of biotechnology quoted from their statements:

“By studying the advantages and disadvantages of this technology to human, we can fulfil the needs of human being;”

“...to know the global trend: as this knowledge is needed:”

“...seems to be linked to day-to-day life”

“...can find out the reasons for diseases:”

“.. can identify the genetic information about humans and plants:”

“....because of basic health of consumers: because it is in the A/L subject:”

“.... very interesting: ... can reduce the problem of developing countries: discover new things regularly:”

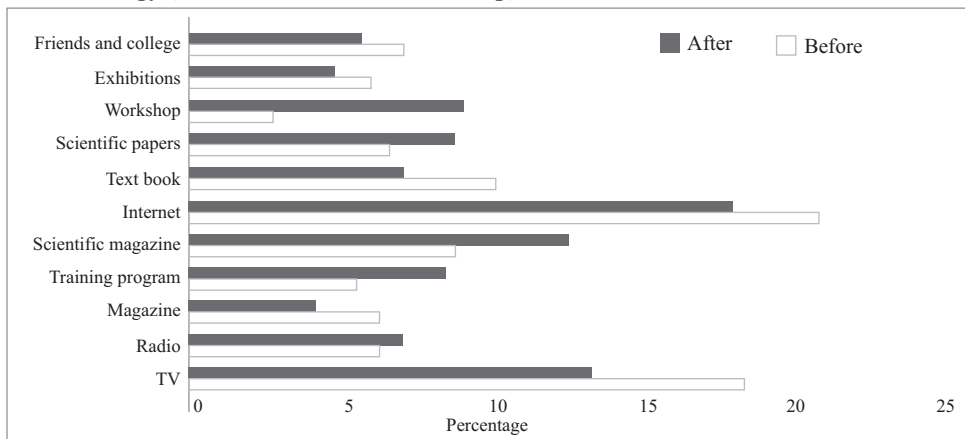
“....can choose the food according to biotechnology knowledge:”

“....it is very important for the present situation and helpful for future life.”

Teachers' selection of information sources about biotechnology

Most of the studies that have focused on how science teachers choose information sources have shown that they use a limited number of readily available sources chiefly due to time limitation and the perception that they lack the skills to properly evaluate and use them (Sun and Liu, 2009). Nonetheless, the present study reveals that most of the teachers (39 teachers, 61.90%) used internet as a source of information (Fig. 2) even before the workshop. This agrees with findings of Fonseca et al. (2012). The choice of information sources is highly influenced by the information literacy of the teachers and the time required for accessing the sources (Williams and Coles, 2007). The teachers have mentioned that they get very limited information about biotechnology through conferences (Fig. 2). This may be due to the limited chance that teachers get to attend conferences locally and at the international level.

Figure 2: Sources of Information Teachers Use to Gather Information about Biotechnology (before and after the Workshop)



Teachers' Literacy Level about Biotechnology

The present study disclosed that the teachers participated in this survey were well-informed about biotechnology ($M = 3.97$, $SD = 0.95$, $t(62) = 8.09$, $p = 0.00$). However, many teachers ($n = 62$, 98.40%) stated that they are interested in participating in training programs in the context of formal biotechnology education. This implies that although the teachers have been on the job for some years ($M = 13.82$, $SD = 7.60$), they still have gaps to fill in their knowledge about biotechnology. Moreover, 60 teachers (95.20%) reported that they are interested in implementing experimental activities as part of biotechnology teaching. This is an important aspect to consider. Many people believe that schools do not have enough facilities to carry out experiments and research activities thereby hindering the teaching-learning process. Since teachers are interested in implementing experimental activities at school, ensuring the availability of facilities would encourage experiments as part of biotechnology teaching and thereby improve quality of learning of the subject.

4. Conclusion

This study carried out among Advanced Level biology teachers in the eastern province of Sri Lanka examined the teachers' beliefs about biotechnology and biotechnology education, the relationship between these two and the factors that affect teachers' beliefs. The teachers believed that biotechnology was interesting and important for the improvement of quality of life and this attitude of teachers influenced their practices in biotechnology teaching. More interestingly, the teachers were aware of GM foods and the controversy over the safety of GM foods. They were willing to buy GM foods if these were healthier than other foods. However, they did not accept as readily the application of biotechnology for medical purposes because of their lack of knowledge about these technologies.

Most teachers believed that biotechnology education was important; and this attitude was influenced by their interest towards the subject and the level of information they had about the subject. Finally, provided that required facilities are available, teachers are prepared to implement experiments and attend training programs on biotechnology as a subject and biotechnology education.

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Appendix

Questionnaire to assess the beliefs of biology and non-biology trainee teachers about biotechnology and its application

- Q1. Age: 18-20 21-23 above 23
- Q2. Gender: Male Female
- Q3. Year of G. C. EA/L exam:
- Q4. The course that you follow in this college:
- | | |
|-------------------|----------------|
| Special Education | Mathematics |
| Primary Education | Islam |
| Science Business | Administration |
- Q5. Year/s of stay in the college:
- Q6. Name of other course/s attended:
- Q7. Future willingness of subject/s to teach: (check all what applies to you) Yes No
- | | |
|-------------------|-------------------------|
| Special Education | Mathematics |
| Primary Education | Islam |
| Science | Business Administration |
- Q8. Do you know what biotechnology means?
- Q9. Do you like to learn about Biotechnology? Yes No
- Reason:
- Q10. Are you interested in participating in training courses in the scope of formal biotechnology education?
- Q11. From which sources do you most commonly obtain information about biotechnology?
- | | | |
|-------------|------------------------|----------------------|
| TV | Radio | Newspapers |
| Magazines | Training programs | Scientific magazines |
| Textbooks | Scientific papers | Workshop |
| Exhibitions | Friends and colleagues | Conferences |
| | | Others |
- Q12. State your level of trust in the following sources to obtaining information about biotechnology.
1. I do not trust it/them at all.
 2.
 3.
 4.
 5. I trust it/them completely.
- | | |
|--------------------------------|-------------------------------------|
| a. Media | b. Scientific magazines |
| c. Pharmaceutical industry | d. Agro-food industry |
| e. Health industry | f. Government agencies |
| g. Scientists | h. Internet |
| i. Environmental organizations | j. Organizations on consumer rights |
| k. Medical doctors | l. Universities |

*Use the following scale for Q13 & Q14.

1-Not at all important

2-.....

3-.....

4-.....

5-Very important

Q13. How important do you think biotechnology is to the quality of life?

Q14. How important do you think biotechnology education is?

Q15. Rate your interest towards biotechnology.

1-I am not interested at all.

2-.....

3-.....

4-.....

5-I am very interested.

Q16. Do you know what Genetically Modified Foods (GMF) are? Yes No

Q17. Would you eat GM food if it is freely available for you? Yes No

Q18. Would you purchase GMF for your consumption? Yes No

Q19. Do you think that GM food is safe to consume? Yes No

Q20. Do you think that GM food can be a solution for world food shortage? Yes No

Q21. Do you think that GM food can be a solution for malnutrition? Yes No

Q22. a. Do think that there will be environmental issues by the cultivation of GM crops?
Yes No

b. If yes, please state them.....

Q23. Are biotechnology/molecular biology tools used in the following fields.

(Tick your response/s)

Forensics

Disease diagnosis

Drug discovery

Germplasm conservation

Phylogenetic studies

Genetic Engineering

Gene therapy and other medical applications