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RESEARCH ARTICLE

Gauging students' perception on biotechnology and cloning: Empirical evidences from India and Tanzania

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ABSTRACT

For over the last two decades biotechnology and its techniques in various fields have attracted much media attention. All over the globe, syllabi have been directed to teach biotechnology and biotechnological techniques to undergraduate and post graduate students in almost all public funded and private universities. Biotechnology is beset with many ethical and social controversies. Earlier, there was much hue and cry at the introduction of 'Genetically Modified foods' and 'Bt Cotton' and even a much-hyped project like the 'Human Genome Project' did not achieve its pace because of ethical concerns.

Social scientists started conducting opinion research on such 'modern technologies' before giving concrete shape to their adoption. In more recent years the issue of public perception, attitude and understanding towards science, in general, and towards specific technologies like genetic engineering, cloning, genetically modified foods, bio-technology and even nuclear technology, is increasing at a fast pace all over the world.

One such study has been carried out registering the perceptions of undergraduate students who are studying biology subject in India and Tanzania, on biotechnology and cloning. The survey was conducted through a questionnaire (partially structured). This analysis revealed that students favoured production of genetically modified foods but they responded that 'biotechnological experiments' should be conducted on plants rather than animals. Furthermore, the students were strongly supportive of medical applications of biotechnology to avoid genetic diseases. Students from the two countries gave similar

responses on some issues but differed on other issues. It is worth mentioning here that, though these perception survey studies are indicative yet these are quite important in framing policies related to the introduction of new technologies and framing strategies for communication/ popularisation of these issues among the general public.

Keywords: Biotechnology, Cloning, Genetic engineering, Perception, Ethics

Introduction

The use of biotechnological techniques like genetic engineering, DNA finger printing, and cloning has become important in the twenty first century from the biological, socio-economic and political point of view. A wide range of sectors such as pharmaceutical, medicine, agriculture, food and environment have been benefited by the use of biotechnological inputs. In most developed and developing countries, ethical and social controversies related to biotechnology are running all along its development and adoption (Reiss and Straughan, 1996).

The issue of public perception, attitude and understanding towards modern technologies like genetic engineering, cloning, genetically modified foods and biotechnology is increasing at a fast pace in many countries. Survey studies to assess qualitative and quantitative aspects of public understanding to these technologies have been carried out in European and other countries (Gaskell and Bauer, 2001), Canada (Einsiedel and Medlock, 2005), United States (NSF, 2002), and Brazil (Massarani and Moreira, 2005). Specific survey studies on issues related to biotechnology have also been carried out (Human Genetics Commission, 2000) on specific target populations, especially students (Lewis and Wood-Robinson, 2000).

Studying the American public, it has been found that they are relatively less knowledgeable and indifferent about genetically modified foods. The study was conducted at Arkansas to determine the extent of knowledge, risks and benefits, and perception about the use of biotechnology and GM foods. Respondents showed partial knowledge and tended to overestimate the number of GM foods and also tended to be familiar with the debates surrounding benefits and risks (Knight *et al.*, 2005).

Coyle and Fairweather (2005) explored the public reception of biotechnology among New Zealand population using Bakhtin's space-time matrix and found that the term 'nature' is a powerful signifier for perception about future of biotechnological techniques such as genetic engineering, xeno-transplantation, cloning and embryonic stem cell research.

In Switzerland, the public is well informed but also sceptical about biotechnology. The study of content analysis of national newspapers, predicts results of knowledge of microbicide trials in South Africa (Cooper, 2008). It has also been found that 82 percent could mention at least one thematic reference to the term biotechnology. However, the percentage of the coverage of biotechnology in print media decreased in Switzerland during 1997 to 2000 (Bonfadelli et al., 2002). During the period Switzerland did not experience street demonstrations on public debate on biotechnology but quite peaceful discussions were held inside regulatory offices. Though the future of biotechnology in Switzerland seemed uncertain the author was not convinced that public debate had ended in the country.

Gutteling (2002) studied biotechnology in terms of differences between the Netherlands and other European countries on political, economic, socio-cultural and media-coverage indicators. In the Netherlands, a large majority of the people expressed trust in government compared to other European countries. It is also worth noticing here that Netherlands has been financially supporting Greenpeace organisations, which have been opposing biotechnological developments.

Many researchers have investigated the public's response to new technologies, perception of British students on biotechnology (Lock and Miles, 1993) and genetic engineering (Gunter et al., 1998), Brazilian (Massarani and Moreira, 2005) and Slovakian students (Prokop et al., 2007). It has also been found that despite poor understanding of biosciences, students all over the world favoured genetically modified foods. Furthermore, the students were strongly supportive of medical applications of these biotechnological developments to avoid genetic diseases, though gender differences in response were also observed. Knight (2008) also found that the public in the US

overestimated about genetically modified foods. Findings also showed concerns about inserting animal genes into plants and concluded that moral and ethical issues will dominate any discussion of foods derived from a mixture of animal and plant genes.

Lock and Miles (1993) investigated the views of British students – both before and after relevant teaching. It was observed that one third of the total sample, and more males than females, did not know what biotechnology or genetic engineering was. Nearly half the sample could not give examples of either biotechnology or genetic engineering. Gunter *et al*. (1998) examined opinions on genetic engineering of plants among British students and results showed that, despite the students' poor understanding of biological science, they seemed less hesitant about genetically modified (GM) food. Chen and Raffan (1999) examined levels of knowledge and attitudes towards biotechnology applications and genetic engineering among British and Taiwanese students. In general, 17-18 year-old students were in favour of genetic engineering applied to plants, but not to animals. In Australia, Dawson and Schibeci (2003) also found that 15-16 year old students preferred genetic modification of microorganisms and plants more than that of animals and human beings.

Similarly, investigations were conducted among Brazilian (Massarani and Moreira, 2005) and Slovakian (Prokop et al., 2007) students. Quantitative and qualitative studies conducted among Brazilian high school students revealed that students were well informed about some of the issues related to biotechnological applications. Most students believed that GM food could be useful and should be encouraged, but they also mentioned the risks involved with it. Furthermore, the students were strongly supportive of medical applications of biotechnology to avoid genetic diseases. Gender difference was also observed among university students' knowledge of and attitudes towards biotechnology in Slovakia. Simon (2011) working on gender issues and utilising data from Eurobarometer (52.1) predicted that males will more likely be aversive to biotechnology if they perceive a threat to their masculinity and increased levels of threat perception will reduce the effects of

knowledge on attitudes.

Though many studies have been conducted on public perception and attitude towards science in India (Raza and Singh, 2007), few studies on observing perception towards modern technologies such as biotechnology, genetic engineering, cloning, etc., have been carried out on specialised populations. The present study is an effort towards this direction to study the perception of the undergraduate students who have been studying biology as one of the subjects at undergraduate level.

Methodology

The students form an important segment of the populace to record their perception, as these students will form a significant section of the future generation, and will be called upon to contribute to the development of the nation and also of science.

A structured questionnaire containing various aspects of biotechnology and cloning was developed for mapping the perception of the students. The questionnaire was designed mostly on Likert scale with a few questions on 'yes' and 'no' pattern and a few more open-ended questions were included. Distribution and collection of questionnaire was preceded by a seminar on research in public understanding of science. The questionnaire was administered among undergraduate students studying biosciences in universities of India and Tanzania. The sample was collected from two universities in India and one university in Tanzania.

Sample Characteristics

The following paragraphs provide information of the demographic details of the surveyed population in terms of their age, gender, education level, sources of information on science, marital status and religion their families. As noticed, in schools and colleges there are more female students opting to study biosciences (especially in India). In the total sampled population 53 percent were male and 47 percent were female students from both the countries, mainly in the age group 17-25 years. There were more female respondents from the Indian sample while the Tanzania sample was more skewed towards male respondents

(29% male and 71% female from India while 68% male and 32% female from Tanzania).

Age-wise distribution reveals that in India students ranged from 17-21 years but in Tanzania the range varied lot (20-45 years), though the frequency at higher level of age was negligible. In the total sampled population about 72 percent were third year students, 15 percent in second year and 13 percent in the first year. In all about 82 percent were unmarried while other 18 percent were either married or living in relationship with other partners. Even marital status for the two countries differs a lot, 98.9 percent Indian students were unmarried whereas 71.7 percent Tanzanian students responded so.

Newspaper (54.7), books (73.7), television (47.8) and internet (76.3) were responded as the main sources of information on the subjects of biosciences including biotechnology and cloning. Access to television, newspaper and magazines was more for Tanzania students while internet and books was higher among India students as source of information. About 34 percent responded that they belong to 'Hindu' religion, about 53 percent 'Christian' and 10 percent were 'Muslim'. Indian sample is dominated by students belonging to 'Hindu' religion (89.7 percent) and Tanzania students (85.5 percent) belonged more to 'Christianity'.

Observations and analytical results

The word 'Cloning' means

In response to a question 'how do you respond to the word cloning?', out of the total sampled population, 69.0 percent from India and 21.4 percent from Tanzania responded that cloning is brilliant science. Though, in total 25.0 percent responded it is helpful for mankind but Indian students were higher in favouring this idea than Tanzanian students (34.5 vs 19.3 percent), 27.6 percent Indian students and 13.1 percent Tanzania students took cloning as exciting while 'acceptable' was responded by 18.4 percent by Indian students and 22.8 percent by Tanzania students. The response for term 'cloning' is 'too new to be sure' or 'playing with God' or 'terrifying' was also responded and percentages for each was slightly higher among Tanzania students compared to Indian.

Table 1 — Students' response to the idea of cloning

Cloning is	Percentage	
	India	**Tanzania**
Brilliant science	69.0	21.4
Helpful for mankind	34.5	19.3
Exciting	27.6	13.1
Acceptable	18.4	22.8
Too new to be sure	10.3	14.5
Playing with God	9.2	10.3
Terrifying	4.6	4.8

In addition, students also responded to cloning as 'unethical', 'disgusting' and 'against nature' and percentages are too small. Table 1 shows the comparative response pattern of the college students from the two countries.

General issues related to cloning

Out of the total sampled population of students, 80.2 percent were in agreement that 'Farm animals are being cloned for high quality meat or milk production' and mean values were 1.90 for India and 1.52 for Tanzania, meaning more favourable in Tanzania. More than 67 percent of the total students surveyed also rejected the idea that 'all forms of cloning research should be banned' and the percentages are 83.9 percent among Indian and 53.1 percent among Tanzania students. The mean value is more skewed towards rejection with low value of SD among Indian students compared to Tanzania. The students did not even favour that 'all forms of cloning research should be banned' and even percentages of responses differ much among Indian (87.4 percent) compared to Tanzania students (55.9 percent).

67.7 percent of the total sampled population said that 'Sheep have been cloned and some of their genes have been altered to produce life-saving human proteins in their milk and this type of animal genetic manipulation and cloning should continue in order to benefit human beings – the mean value was 1.60 for Indian students and for Tanzania students it is 2.20 and even standard deviation (SD) is higher among Tanzania students.

42.7 percent of the total respondents were in agreement that infertile couples often long for a child that is genetically their

own, cloning one of the parents would be an acceptable way to solve their problem of childlessness. But the percentages differ much among Indian students (59.8 percent) and Tanzania students (32.4 percent) with mean values 2.33 and 3.23 for Indian and Tanzania students respectively. As high as 66.8 percent also accepted in vitro fertilization or 'test tube babies', which has enabled numerous childless couples to have children of their own with considerable difference between Indian (87.4 percent) and Tanzania (54.5 percent) students.

Table 2 — Comparative response pattern of students from India and Tanzania on various issues of cloning

Issue	**India**				**Tanzania**			
	Agree	Disagree (%)	Mean	SD	Agree	Disagree (%)	Mean	SD
Farm animals are being cloned for high quality meat or milk production.	72.4	17.2	1.90	1.543	84.8	11.0	1.52	1.289
All forms of cloning should be banned.	4.6	83.9	4.59	1.015	24.1	53.1	3.58	1.662
All forms of cloning research should be banned.	6.9	87.4	4.61	1.090	17.2	55.9	3.77	1.745
Sheep have been cloned and some of their genes have been altered to produce life-saving human proteins in their milk. This type of animal genetic manipulation and cloning should continue in order to benefit humans.	79.3	9.2	1.60	1.258	60.7	24.1	2.20	1.694
Infertile couples often long for a	59.8	26.4	2.33	738	32.4	44.1	3.23	737

child who is genetically their own. Cloning one of the parents would be an acceptable way to solve their problem of childlessness.								
IVF (in vitro fertilisation or 'test tube babies') has enabled numerous childless couples to have children of their own. IVF is an acceptable method of human reproductive technology.	87.4	3.4	1.32	0.906	54.5	27.6	2.46	1.733
SD= Standard Deviation								

Social, biological and economic issues

On the issue related to cloning, 85.8 percent of the total sample thought that 'cloning is expensive' with the percentage was slightly higher among Tanzania students. 58.6 percent students equally from India and Tanzania responded that the cloned organisms have less survival rate but mean value differs for the two countries i.e., mean 2.08 and SD 1.412 for Tanzania and mean 2.15 and SD 1.509 for Indian students.

Out of the total sampled population, 44.4 percent responded that cloned organisms are 'prone to infections' with almost similar trends of response behaviour for students of the two countries. On the other hand, 39.9 percent students also perceived that cloned organisms 'can develop tumor' with 34.5 percent for Indian and 40.0 percent for Tanzania students. Cloned animals sometimes 'die mysteriously' was also perceived almost equally by students from the two countries with mean value 2.45 for Indian and 2.27 for Tanzania students. Cloned animals 'look healthier but otherwise' (45.7 percent total for

total sample) -- 40.2 percent for Indian and 49.0 for Tanzania students (see Table 3).

Cloning of animals and human beings

On the issue of cloning of endangered species, 56.9 percent of the total students recommended cloning of endangered species of plants and animals and 28.9 percent said no to it. There is a marked difference in response behaviour of students from the two countries, the Indian students were higher in percentage (82.8 percent) saying 'yes' to cloning of endangered species whereas only 41.4 percent Tanzania students favoured it.

In response to religious permission for cloning, only 12.1 percent responded that their religion (irrespective of religion) permits cloning of animals while 48.3 percent said that their religion does not permit doing so. Interestingly, there is no marked difference in percentages for the two countries (India 13.8 and Tanzania 11.0 percent) in spite of the fact that the Indian sample is 'Hindu' dominated and Tanzania sample is 'Christian' dominated.

Table 3 — Comparative response pattern of students from India and Tanzania on various social, biological and economic issues of cloning

Issue	**India**				**Tanzania**			
In cloning	Agree (%)	Disagree	Mean	SD	Agree (%)	Disagree	Mean	SD
Cloning is expensive	82.7	3.4	1.41	0.968	87.3	1.4	1.28	0.767
Clones can develop tumor	34.5	10.3	2.52	1.253	40.0	6.9	2.34	1.201
Clones look healthier, but otherwise	40.2	20.7	2.61	1.516	49.0	10.4	2.23	1.335
Clones sometimes die mysteriously	43.6	16.1	2.45	1.449	46.9	10.4	2.27	1.327
Survival rate is less	58.6	16.1	2.15	1.509	58.6	12.4	2.08	1.412
Clones are prone to infections	43.6	18.4	2.49	1.497	44.9	15.2	2.41	1.342
SD= Standard Deviation								

But there is marked difference in 'no' response, i.e., 'religion does not permit cloning of animals', when compared for two countries. Only 25.3 percent Indian students responded 'no' to it while 62.1 percent Tanzania students responded no to this query.

To the query 'Should human being be cloned' the response behaviour slightly changed in comparison to the earlier query. More than 20.0 percent of the total sampled population responded that 'human being should be cloned' and 55.2 percent was against the cloning of human beings while 10.8 percent also perceived human cloning as 'unethical'. There is a difference in the response pattern of students from the two countries which shows that 27.6 percent Indian students recommended human cloning whereas 21.4 percent Tanzania students favoured it and the sum of response behaviour is depicted below (see Table 4).

Expert's involvement in decision making

In response to a question 'who should be involved in any public debate and the final decision-making processes regarding cloning', the general trends of response among students in the two countries was the same with difference in the magnitude in response percentages. As high as 88.3 percent students responded that scientists should be involved in the debate and decision making regarding cloning. Country-wise comparative analysis shows that 92.0 percent of Indian students and 85.2 percent Tanzanian students favoured scientists and medical to be involved.

Table 4 — Comparative response pattern of students from India and Tanzania on cloning of humans and animals

Issue	**India**			**Tanzania**		
	Yes	No	Unethical	Yes	No	Unethical
Should human beings be cloned	27.6	43.7	16.1	21.4	62.1	7.6
	Yes	No	Does not say anything	Yes	No	Does not say anything
Does your religion permit cloning of animals	13.8	25.3	37.9	11.0	62.1	10.3
Do you recommend cloning of endangered species of plants and animals	82.8	8.0	--	41.4	41.4	--

On the other hand, students did not agree that political persons should be involved in the discussion (60.8 percent). 70.1 percent Indian students and 55.2 percent Tanzanian students responded 'no' to political leadership for decision making debates. Students did favour 'ethical experts' (59.9 percent) and religious leaders (39.8 percent) to be involved in the debate on cloning. Even common man has been preferred over political and religious leaders for the debate and decision making related to cloning and biotechnology. The details of analysis have been shown in Table 5 below.

Response towards genetically modified crops

Similarly, response has also been recorded on various aspects of genetically modified (GM) crops. On the issues related to GM crops 66.4 percent of the total students responded that these are 'insect tolerant', 70.7 percent regarded these crops as 'economically viable'. But for other features, like GM crops contribute lesser greenhouse gases (23.3 percent), these crops are more toxic (24.6 percent), GM crops cause allergy (35.4 percent), GM crops contain lesser nutrients (24.6 percent), the percentages are less. More percentage of students (59.9) favoured that genetically modified crops' products should be marked as 'GM crops', 7.8 percent responded that these should not be marked, but 10.3 percent responded that 'it does not make any difference'. Response pattern in respect to respondents from two countries is given in Table 6.

Table 5 — Who should be involved in any public debate and the final decision-making processes regarding cloning?

	India		Tanzania	
	Agree	Disagree	Agree	Disagree
Scientists	92.0	1.1	86.2	2.1
Ethical Experts	58.6	14.9	60.7	11.0
Economists	39.1	29.9	55.9	20.7
Religious leaders	25.3	57.5	53.1	32.4
Political leaders	11.5	70.1	28.3	55.2
Common people	50.6	28.7	36.6	31.7

Table 6 — Comparative response pattern of students from India and Tanzania on various issues of genetically modified crops

Issue	**India**				**Tanzania**			
Genetically modified crops are:	Agree	Disagree	Mean	SD	Agree	Disagree	Mean	SD
Insect tolerance	77.0	4.5	1.55	1.083	60.0	4.9	1.90	1.175
Economically viable	64.4	6.9	1.85	1.240	74.4	1.4	1.54	0.949
Causes allergy	19.5	29.8	3.21	1.721	44.9	17.2	2.45	1.478
Contain lesser nutrients	11.5	70.1	4.17	1.379	32.4	35.8	3.07	1.654
More toxic	17.2	42.5	3.55	1.465	29.0	32.1	3.08	1.576
Contribute lesser greenhouse gases	25.2	14.9	2.79	1.255	22.1	23.4	3.03	1.351
Reduce biodiversity	32.1	42.5	3.21	1.721	34.5	37.2	3.06	1.696
SD= Standard Deviation								

In response to a query whether there should be a place for ethics in science, one third of the total sampled students were affirmative that science should be carried out taking into account the ethical issues involved. And 20.7 percent responded that scientific research should be carried out independent of ethics, but high percentage of total students, i.e., 42.7 percent, responded that ethics should have place in science only to some extent. This is evident from the fact that most students did not support the idea of human cloning (55.2 percent).

It has been observed that like in many other countries, students from these two countries are also well informed on biotechnology and cloning. These students favoured introduction of new technology like genetic engineering, biotechnology or cloning. Students favoured both animals and plants as experimental material for carrying out biotechnological experiments.

Discussion

Researchers all over the world have put in efforts to know students' perception and attitudes towards new technologies like nuclear technology, biotechnology, genetic engineering, nanotechnology, etc. The younger generations have also shown their interest in these technologies.

Gunter *et al.* (1998) examined opinions on genetic engineering among British students and results showed that, despite the students' poor understanding of biological science they seemed less hesitant about GM food compared to adult respondents. Chen and Raffan (1999) examined levels of knowledge of and attitudes towards biotechnology applications and genetic engineering among British and Taiwanese students. In general, younger students were in favour of genetic engineering applied to plants, but not to animals. Australian students were studied by Dawson and Schibeci (2003) and it was found that 15–16 year old students found genetic modification of microorganisms and plants more acceptable than that of animals and humans.

Regional differences are evident in case of the present studies with Indian students responding with a pro-cloning attitude as seen in Table 1. Results from the present study have also shown that more Indian students feel that experimental material for biotechnology should be plants and animals both, in comparison to Tanzania students.

Cloning of farm animals is acceptable more if it is done to increase the meat or milk output. Even use of animals is accepted more if done for the benefit of human existence. The response pattern in Table 2 shows that on some issues Indian students responded with agreement while on some issues Tanzanian students scored higher for agreement.

Lewis and Wood-Robinson (2000) concluded on similar lines and explored the main factors on which students made their judgments, which are usefulness of the technique or the product, the type of organism involved, and concerns that the process and/or product were unnatural. For more abstract and controversial issues, the students remained silent and responded 'not sure' rather than favouring or disfavouring the technology.

Raza *et al*. (2002) have argued that understanding of scientific or any other phenomena is a cultural process and socio-cultural aspects play an important role in the flow of information. The response behavior of the students from both the countries shows that even though these students have been studying bio-sciences, yet their response was rooted in their

cultural norms. Students termed human cloning as 'unethical' while calling it 'brilliant science'; they even responded that experiments can be conducted on animals and plants but not on human beings, they did respond that their religion did not permit their own cloning. On the one hand, these students highly recommended the cloning of endangered species, but on the other they responded that 'ethical implications must be considered prior to introduction of biotechnology and cloning' or 'cloning and biotechnology can be adopted with all limitations'.

Researchers have also carried out studies on *usefulness* and risk perception of different sets of populations. Lan (2009) established that the Chinese people are extremely positive in their evaluation of the usefulness and moral acceptability of various applications of biotechnology, whereas the European public has broad and firm understanding of the risks involved. Massarani and Moreira (2005) observed that Brazilian students believed that transgenic food could be useful and that it should be encouraged, but also aware of the risks involved. Students in Brazil were strongly supportive of the labeling of transgenic food.

Students in the present study were also receptive to risk appreciation and more students responded that cloning is more expensive and cloned organisms have lesser survival rate. Other risks like cloned organisms are prone to infection or can develop tumor, were more prevalent among students. The response behaviour from both the countries showed similar pattern with minor difference in percentages (Table 3).

On the issue of genetically modified crop, more Indian students were in agreement that the GM crops are 'insect tolerant' as compared to Tanzanian students. On the issues, 'GM crops contribute lesser greenhouse gases' and 'GM crops reduce biodiversity' students from both the countries had similar views and were in disagreement with the issues. There was a marked difference in response pattern on other issues like, 'GM crops are economically viable' or 'GM crops cause allergy' or 'GM crops contain less nutrients' or 'GM crops are more toxic'. On these issues students from Tanzania university were more in agreement with all the statements when compared to Indian counterparts.

More interestingly, about 20 percent students responded that they had changed their opinion about cloning since they first heard about it, but majority of students responded that they had

not changed their opinion. This also demonstrates that the understanding of any phenomenon is more rooted in the cultural environment of the public rather than just absorbing it through books and texts. This also confirms the hypothesis put forth by Raza et al. (2002) that even the purpose of 'public understanding of science' is impossible only through 'education' though it plays an important role in people's understanding. Crossing the barriers of one culture (scientific culture) to peoples' culture, supplemented by raising the level of education through modern system may serve a better purpose.

It will not be out of context to mention here that survey studies have gained popularity all over the world. In spite of all limitations, survey studies are important tools to carry out studies in all aspects ranging from economic, social, political, scientific, etc. The results shown are all indicative and can provide important directions to planners and policy makers, rather than taken otherwise. Future policies and planning can take lead from the outcome of investigations through such studies. The outcome of the present study can provide inputs to direct the science communication policy or refresh the teaching methodology so that the message can reach the target audience in the right perspective.

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