Negotiating ethical issues in Biology: three case studies

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Abstract

This paper attempts to answer the questions as to what are the chief transactional strategies for negotiating ethical issues in high school biology classroom. One of the major aims of the paper is to highlight the components of teachers' pedagogical content knowledge (PCK) reflected in their transaction of ethical issues. Using the ethical matrix and Toulmin's model of scientific argumentation the paper dissects three case studies. It was found that teachers' knowledge of argumentation (KArg) and knowledge about ethics (KET) are the components of PCK that can significantly affect teachers' arguments related to ethical issues. The quality of teachers' arguments varies and is contingent upon their beliefs about a technology, knowledge about argumentation, and notions about ethics. Implications are broadly drawn for science teacher education at high school level; mode of presentation of ethical issues in the classroom, textbook writers and curriculum designers.

Keywords

Ethical issues, Biological Sciences, pedagogical content knowledge, scientific argumentation

Résumé

Ce document tente de répondre à la question de savoir ce que sont le chef des stratégies pour négocier transactionnel des questions éthiques en cours de

biologie de l'école secondaire en classe. L'un des principaux objectifs du présent document est de mettre en évidence les éléments de contenu pédagogique des connaissances (PCK) reflétées dans leur opération de questions éthiques. En utilisant la matrice éthiques et Toulmin's model of arguments scientifiques le papier dissèque trois études de cas. Il a été constaté que les connaissances des enseignants sur l'argumentation (KArg) et des connaissances sur l'éthique (KET) sont les composants de PCK qui peuvent affecter de manière significative les enseignants' arguments liés aux questions éthiques. La qualité des arguments des enseignants varie et dépend de leurs croyances sur une technologie, des connaissances sur l'argumentation, et notions sur l'éthique. Implications sont largement définies pour l'enseignant de sciences de l'éducation au niveau secondaire; le mode de présentation des questions éthiques dans la salle de classe, les auteurs de manuels et les concepteurs de curricula.

Mots-Clés

Questions éthiques, sciences biologiques, contenu pédagogique des connaissances, argumentation scientifique

Introduction

Science and Ethics, an alliance between two entirely different and rather converse disciplines both in their processes and intent is hard to imagine. As we know that sciences belong to a study discipline that is objective, rational and empirical in approach, whereas 'ethics' provides us with the knowledge about 'right' and 'wrong' along with the reasons behind choosing particular actions over others by adhering and following different modes of ethical enquiry (Reiss, 1999). A common forum where both the disciplines merge is the realm of socio-scientific issues (SSI) that provides opportunities for discussion and debates on some of the issues related to science and technology that impact our society. This inter-disciplinarity is important to maintain in the present day science curriculum in order to attain its humanistic goals. In this regard, the role of science teachers is indispensable as teachers are chief translators of the curricular aims and objectives. Therefore, it would be interesting to note the ways and means through which the teachers present these issues in the classroom predominantly the ethical component inherent in these issues. There have been many studies related to SSI having implications for science teaching and teacher education (Zeidler, Sadler, Simmons & Howes, 2005; Sadler, Amirshokoohi, Kazempour & Allspaw, 2006; Evagorou & Osborne, 2013; Saunders & Rennie, 2013), but dealt in a generic perspective the ways of addressing SSI in the classroom. However, a lacuna that still persists is the teacher knowledge in the area, their beliefs and conceptions about ethical issues which could

greatly impact their transaction of these issues in the classroom. All these aspects taken together constitute the pedagogical content knowledge (PCK)[1] of teachers with respect to ethical issues. Therefore, the present study attempts to understand the components of PCK that impact teachers' arguments with respect to ethical issues in Biological Sciences, as well as the structural quality of such arguments.

Place of Ethics in Science

There are a spectrum of arguments on the inclusion of ethics in science. The arguments that go against the integration of ethics and science are based on the processes and methods employed, which are very different for both the disciplines and can nowhere be equated, also sciences are fact-based whereas ethics talks about whether a particular action ought to be done or not. Sciences have provided us with the means for example to generate nuclear power or say methods for crop improvement, but whether these should be applied or not is something which is outside the realm of sciences and enter into an ethico-moral domain. However, the inclusion of this 'ethics' component in science is controversial as some say that it would lead toward a retrogressive or anti-technological development. On the other hand, another group of researchers argue that values and ethics are inseparable from sciences and provide evidence for it, such as observance of truthfulness and honesty in reporting the results of an experiment, communicating one's findings amongst the fellow scientists (communism), critiquing one's own findings (organised skepticism), as well as universalism. Besides, the type of scientific research that is being promoted is deeply affected by the ethos of the organization that supports and funds it. Various other extraneous factors co-determine the fate of research that occurs, such as vested interests of the stakeholders belonging and favouring a particular cadre of population, etc (Reiss, 1999). However, many scientists and social philosophers vie for the inclusion of ethical component in sciences along with some science educators who have tried to integrate this component of ethics in science via socio-scientific issues (Goldfarb & Pritchard, 2000; Zeidler, Walker, Ackett & Simmons, 2002) so as to initiate ethical debates in the classrooms and foster an ethical understanding amongst the learners for a scientifically literate citizenry. With the incessant rise in upcoming new technologies, knowledge in the area of ethics becomes even more important, as the right decisions need to be taken regarding the ethically appropriate usage of a particular technology which would have a repercussion on the larger society. There could be different ways of reaching an ethically sound decision which depends upon the value orientation of an individual along with the ethical theory that is being adhered to.

1 PCK refers to one of the knowledge components of a teacher's knowledge repertoire comprising of the most regularly taught topics of one's subject area and the most useful forms of representations such as by way of examples, analogies, experiments, demonstrations, etc. so as to make the topic comprehensible to the students (Shulman, 1987)

Therefore, training in ethical ways of understanding and decision-making is required in order to tackle these issues of global significance. Different researchers have adopted and rely upon different ethical frameworks for developing an ethical mode of thinking and decision-making with regard to ethical issues such as Beauchamp and Childress (2008) have suggested four principles of ethical thinking: ***Beneficence*** (promoting good), ***non-maleficience*** (avoiding harm), ***autonomy*** (maximising the freedom of individual and community), and ***justice*** (acting fairly). Similarly Reiss (2003, 2006) presented four frameworks for ethical thinking viz., consequences, autonomy, rights and duties, and virtue or care based ethics. All these moral principles are general in character and do not take into account certain embedded aspects such as culture, ethnicity, and gender that also contribute to the understanding about role of ethics in sciences. In a multi-cultural society of today taking account of all such factors is important as they help in the generation of different world views along with the indigenous understanding on the ethical issues. Such pluralistic views should be discussed, and wherever noticed any kind of misconception or altered perceptions should be checked and corrected by providing a scientific explanation for it.

Addressing ethical issues in a science classroom - Review of Literature

Ethical issues in Biological Sciences need to be addressed for their role in enhancing scientific learning and scientific literacy amongst students (Cross & Price, 1996; Pedretti, 2003; Zeidler et al., 2005). Some of the models such as one proposed by Burnham and Mitchell (1992) included five stages in order to reach an ethical conclusion, viz., observation, questioning and hypothesising, information gathering, analysis and ethical deliberation, ethical decision making. Knowledge about students' own worldviews also plays an important role in determining the kind of ethical conclusion arrived at and a teacher should try to inquire into it and share her own opinion as well with the students (Oulton, Dillon & Grace, 2004). Case-based approaches to teaching of moral and ethical issues have also been advocated for basing the scientific concepts into real-life events and happenings and thus generating a discussion in the classroom amongst the students about the possible impact of a particular research or divulsion of an inherent fallacy or myth in the arguments generated for finding out the reasons and logistics behind it. Many theorists and pedagogues have suggested different means of overcoming the difficulty of teaching ethical issues by the creation of artificial contexts in the form of role plays, or viewing a movie/play/documentary by making use of multi-media (Wilmott & Bryant, 2005). Due to the growing concern for the place of these ethical issues within the science curriculum, there has been an increasing emphasis on teaching scientific content by relating it to the daily-life experiences of the learners. This has given rise to a 'situated learning' approach to Biology teaching (Gilbert, 2006; Van Aalsvoort, 2004). Such an approach is also said to improve student motivation

(Sadler, 2009). The discussion about the socio-ethical aspects related to science and technology will help in unearthing certain traditional and indigenous ways of thinking and practicing resulting in the promulgation of a multicultural view of science education. Such a paradigm shift in the curricular approach of teaching science connects to the students' value systems, sense of ethics and moral reasoning (Zeidler & Sadler, 2008). Some researchers have stated the role of argumentation in the resolution of such controversial issues (Taylor, 1996; Fuller, 1997). In order to bring about this radical change in science teaching and learning from a positivist perspective to socially constructed knowledge form, the knowledge and use of argumentative practice plays a predominant role (Driver, Newton & Osborne, 2000). It has already been proven that science classrooms sans argumentation have a negative impact on the students' critical thinking abilities especially with respect to understanding of socio-scientific ethical issues (Solomon, 1991; Norris & Phillips, 1994).

The three major ethical theories that have largely been referred to in the text related to ethical issues include the ***Virtue theory*** which was for the first time given by Aristotle (384 B.C to 322 B.C) as a theory of moral conduct in the society. Which actions are considered good and moral and which ones bad or amoral formed the crux of the theory. Then, the ***Deontological theory***, which lays more stress upon the observance of one's duty toward oneself as well as toward others, and the ends do not justify the means. One of the greatest proponents of this theory is Sir Immanuel Kant (1724-1804) who had named it as 'Kant's Categorical Imperative'. Another principle in this list regards the consequences of a particular action as the major determinants of its morality, such that an act is considered as moral or ethical if it is supposed to benefit maximum number of people or at least cause no harm to others. This is referred to as the principle of ***Utilitarianism*** (Mepham, 2008). However, no theory can be regarded as perfect and one cannot just rely on a single theory during ethical decision making and demands the incorporation of a ***pluralistic framework*** which is democratic (Minkoff & Baker, 2004). Such a kind of framework is required for every country that is moving toward building a liberal, libertarian and equitable society where everyone has a say in the collective decision-making of the state. However, these theories have just formed the basis of our analysis of the teacher's arguments which would have been difficult without referring to any. Thus, using this framework we in our present study set out to explore and articulate the teachers' own understanding, apprehensions and their distinctive ways of dealing with these issues of ethical relevance in their classrooms.

Methodological Framework

Objectives & Research Questions of the study

The aim of the present study is to highlight the components of teachers' PCK that

are possibly present in their arguments about ethical issues, as well as the structural quality of such arguments. The major research questions guiding the present study can be presented as, (i) Which components of PCK are possibly present in teachers' arguments about ethical issues?; and (ii) what is the structural quality of teachers' arguments with respect to ethical issues?

Context of the study

The study has been conducted in the Delhi state region of Indian Subcontinent. The schools chosen are coeducational and offer Biology as a subject at high school level. The data collected for the present study includes teachers' responses and arguments on some of the ethical issues in biological sciences therefore a majority of the responses coming from teachers as well as students side are highly context specific and are affected by the socio-cultural background of state and societal norms of the region.

Participants

A multiple case-study design was adopted to cater to the research questions and aims of the present study. The participants were selected based on an initial survey wherein the high school teachers were interviewed for their knowledge and interest in the area of ethical issues in Biological Sciences. Of those selected after the initial survey, the case studies of three high school Biology teachers working in three different schools of Delhi region, India have been presented. All of them are female. Table 1 presents the background information of the three participants in the study. For maintaining confidentiality, the participants have been given pseudonyms.

Table 1

Background information of Cases

	Saju	**Geeta**	**Ananta**
Educational Qualifications	Masters in Science (M.Sc)	Masters in Science (M.Sc)	Masters in Science (M.Sc)
Pre-service Teacher Education	Bachelors in Education (B.Ed)	Bachelors in Education (B.Ed) & Masters in Education (M.Ed)	Bachelors in Education (B.Ed)
Teaching Subject(s)	Biology	Biology	Biology
Teaching Experience	20 years	30 years	15 years
Gender	Female	Female	Female

Data Collection

The data was collected using a multi-method approach as is evident of a case-study method. Another reason for adopting a multi-method approach was to articulate PCK which is a variant of teachers' knowledge in a better way as teachers' knowledge is said to be a complex structure and cannot be assessed by just one instrument (Kagan, 1990). Moreover, a holistic picture of PCK of any teacher can only be drawn when we have a combination of means for collecting data about teachers' decision regarding choice of teaching-learning strategies for a particular topic, choice of the content for the students, lesson planning schemes and pedagogy, subject matter knowledge, their beliefs, their difficulties and reasons behind them (Baxter & Lederman, 1999). The various sources for data collection included class-room observations along with detailed class notes and teacher-student interaction, in-depth interviews with the teachers that were audio-recorded and transcribed, questionnaires, informal conversations with teachers and their students, teacher diaries and some reflections by them. The researcher observed one complete unit on Reproduction as a non-participant observer that included almost four class periods with each case. The ethical issues within the unit identified by the researcher were mostly related to amniocentesis, contraception, MTP (Medical Termination of Pregnancy), IVF (In-Vitro Fertilization), and HGP (Human Genomic Project).

In-depth interviews

Interviews served as a major source for drawing out teachers' knowledge, understanding and beliefs with respect to the various ethical issues. These interviews were open-ended and without any prior set of questions, rather theme based related to each of the ethical issues. The interviews were more of a discussion and argumentation sort rather than plain dialogical or conversational and hence amounted to around three to four hours for each of the study participants. The themes on which interviews were taken included ethical issues related to the procedures of amniocentesis, contraception, IVF, GM crops, GMOs, HGP etc. All the interviews were audio recorded and transcribed verbatim.

Data Analysis

The data was analysed based on: (a) Coding data and (b) Argument analysis. Firstly, the data gathered from classroom observations, class notes and un-structured interview transcripts was coded for the type of arguments, ethical theories and PCK components. Some of the codes were pre-empted by reviewing the literature available in the area of pedagogical content knowledge, while the rest emerged during the course of data analysis. A list of codes that emerged during the process of data analysis display the varied dimensions of teachers' PCK with respect to ethical issues (Table 2).

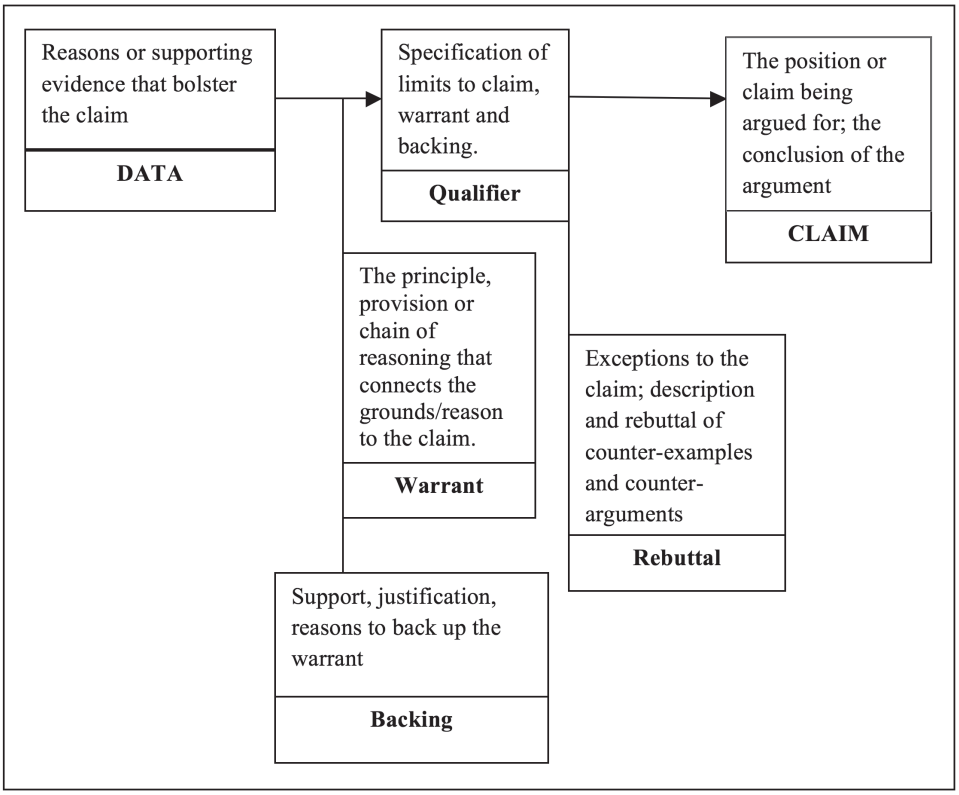
Table 2

List of Codes and Knowledge Categories

S. No	Teacher's Knowledge Category	Description	Code
1.	Subject-matter-Knowledge	This represents the knowledge category of the case with respect to knowledge of the subject, content knowledge, knowledge about the subject's inter-relations with other allied subjects (Integrated subject), as well as applications of subject knowledge in daily-life.	SMK
2.	Teacher's Beliefs	This refers to teacher's conceptions, notions, views, or maybe conventional beliefs about a particular ethical issue. This is a very dynamic category of teacher's knowledge in terms of inter-personal variations in the belief structures of the teachers with respect to a single ethical issue.	TB
3.	Knowledge of Transactional Strategies	The category of teacher's knowledge about the different ways of transacting a topic in the class room and includes the method of teaching-learning adopted, such as, lecture method, lecture with student participation, completely interactive or inquiry based, discussion oriented, problem-solving, etc.	KTS
4.	Knowledge of Curriculum	Teacher's knowledge about the curricular goals, short-term and long-term objectives, framing of the science curricula and the hidden agenda of socio-political structures in the society, place of ethical issues within the curriculum and the treatment given to them.	KCur
5.	Knowledge of Students' Understanding	Teacher's knowledge about the ways students understand better, their difficulties in understanding of particular topics, their misconceptions and common mistakes made by students within the topic boundary.	KSU
6.	Knowledge of Context	Teacher's knowledge about the institution's environment, administration, infrastructure, about class room culture, knowledge about the broader community, its practices, that could in anyway hinder or facilitate teaching-learning.	KCon
7.	Knowledge of Assessment	This refers to the different assessment practices adopted by the teacher with respect to assessing student understanding vis-à-vis ethical issues in Biological Sciences.	KA
8.	Knowledge of ethical theories/Role of ethics (in general & in Science)	This is the teacher's knowledge about the various ethical theories, such as virtue, utilitarian, deontological, etc. this might not exist in such complex terminologies but may be implicit in the statements made by them while taking a class, or during an interview session.	KET
9.	Orientation toward Science Teaching	This includes teacher's own motives and purposes of teaching science which could be very different from the general objectives of science teaching. this category of knowledge takes into account teacher's personal interests, motivation, and criteria for teaching science.	OST
10.	Knowledge of Ethical Argumentation (raising arguments/initiating argumentation/ resolving)	This refers to teacher's knowledge about the valid ethical arguments with respect to a specific ethical issue.	KArg
11.	Knowledge about Nature of Science	It refers to the teacher's nature of science understanding which includes the various sub-themes, some of which have been covered in the present study.	KNOS

Since the major form of data collected during the present study was qualitative and descriptive in nature and consisted mainly of arguments in textual or oral form, therefore argumentation analysis seemed to be the viable means for analysis. Argumentation analysis refers to coding a given argument for its different structural components by using the *Toulmin's model of argument analysis.* It is one such method developed by Stephen Toulmin (1958) which helps in analysing the quality of any argument by breaking it into six different components viz., data, claim, warrant, backing, qualifier and rebuttal (see figure).

FIGURE



Toulmin's Model of Argumentation (Toulmin, 1958)

The 'claim' here presents the main thesis or the controlling idea, whereas the 'data' provides the support for the claim by providing certain evidence and grounds for its occurrence. 'Warrants' are the accepted beliefs or assumptions that are often implicit and mainly support the data in one form or the other. 'Backing' helps in providing support to the warrant and usually is normative in nature, such as universal theories,

rights, rules and regulations, etc. 'Qualifiers' determine the probability of truthfulness of the claim and the incidents when the claim holds true. Lastly, 'rebuttals' are the instances where the claim does not hold true and help in making a stronger argument. It is generally said that arguments that have all these six components inherent in them are the strongest arguments and qualitatively richer to those where any of these components goes missing. The rubric for analysis based on Toulmin's model developed by Erduran, Simon and Osborne (2004) has been adapted for the analysis of teachers' arguments in the present study (see Table 3).

Table 3

Rubric for assessing the quality of Argumentation

LEVELS OF ARGUMENT	QUALITY OF ARGUMENT
LEVEL I	Argument consisting of a simple claim based on a personal belief without any evidence/data/warrant/ backing/rebuttal
LEVEL 2	Argument consisting of a claim supported with data/evidence/backing which provides a valid reason for the claim but having no rebuttal
LEVEL 3	Argument with a series of claims or counter claims with data/warrant/backing that support the claim but having only a weakly identifiable rebuttal which indicate a pre-ponderance toward the validity of claim
LEVEL 4	Argument having several claims and counter-claims supported with evidences and data and having a clear rebuttal which refutes the claim. Such an argument can also indicate a state of ethical dilemma
LEVEL 5	An elaborated argument with more than one rebuttal indicating a true engagement with the argument and approximation to a consensus or truth (leading toward ethical decision-making)

Note. Adapted from Erduran et al., p. 928

Results

Data analysis revealed some of the salient and distinct aspects of PCK with respect to ethical issues in Biological Sciences that advance our present understanding of the construct. These are: (a) Teachers' Knowledge of Argumentation (KArg) forms the major component of PCK with respect to ethical issues in Biological Sciences and has a great impact over transaction of ethical issues in the classroom. (b) Teachers' knowledge about 'ethics' and its role in science has a major influence over the arguments that they make as well as the stance taken with respect to any technology at hand. (c) The quality of arguments varies across different teachers depending upon the quality of data, claim, warrant, backing, qualifier, and rebuttal provided in an argument.

Results about RQ1: PCK Components in teachers' arguments

Knowledge of Argumentation (KArg) emerged as a major component of Teachers' PCK influencing the transaction of ethical issues in the classroom. The major pedagogical approach adopted by all the three cases in order to deal with the ethical issues in their classrooms happens to be raising arguments that help in generating an ethical discourse as well as provide a clue about their subject-matter knowledge vis-à-vis these issues. Therefore the representation of each case's PCK would be based on an ethical analysis of the arguments generated both in the classroom as well as during in-depth interviews. This constitutes the major portion of the case's topic-specific PCK. The arguments however vary in content and nature as some may sound to be logical, some providing evidence to prove a point; some may highlight the belief structures or underlying notions. The arguments also have an ethical component attached to them and is therefore linked with some or the other ethical frameworks chosen for the present study.

The three case studies clearly indicate that the predominant form of PCK represented by each one of them pertains to different kinds of argumentation strategies which are directly related to the subject matter knowledge that they possess. The one who has sound subject-matter knowledge seems to be delivering better framed arguments than the other. However the way in which these arguments are presented also vary from case to case and have a visible pedagogical impact, such that in case of case I, Saju, the ethical arguments are merely listed in a 'statement' form for example, "At many places in this country the technique has been misused in detecting the sex of the unborn child leading to aborting of the female foetuses" (Ethic of Justice & Dignity of the female fetus), "An ideal contraceptive is one which is user friendly, effective, and with least side effects" (Utilitarian).

These statements although have an ethical component attached to them, but is not reflected in the way in which they are presented. Thus, the teacher may be having the subject-matter knowledge (SMK) but lacks the skill of sensitising the students about the ethical issues attached to the topic with a specific purpose of creating an ethical understanding and scientific literacy. On the other hand, case 2, Geeta is much better in her way of putting forth the arguments before her students, a sample of the arguments put forth by her in the classroom can be taken as follows. "Why the female is always blamed for giving birth to the girl child?", "Do parents have any right to determine the sex of the unborn baby?", "Why in this country are females always the victims of such procedures just because nature has assigned them this task of giving birth?", "Why are males given so much preference and females regarded as a fairer sex?".

Such points raised by the case are actual instances of 'argument' and 'debate' and the manner in which these are presented also vehemently touch some of the grave issues of gender inequality, female feticide, ethic of care and concern for the girl child

that the earlier case could not do. As is noticeable, that the arguments are usually put before the students in the form of a question that have the potential of triggering an ethical enquiry amongst the students rather than providing them with a ready-made solutions that are given and uncontested (as was evident in case 1, Saju). The third case, Ananta also adopts a similar way of presenting her arguments as case 2, some of the arguments presented by her can be taken as "Why should we be worried about female foeticide?", "Is it a sign of a healthy society?", "Should the Government Ban this Technique of Amniocentesis?", "Should the couples have the right to decide whether to have a girl child or a boy child?", "Around 40-50 million abortions take place every year, in that case is it good or bad to legalise abortions?".

The above arguments made by the case clearly indicate that she possesses an adequate SMK with respect to the topic (Amniocentesis in the present case) and is also aware about the misuse of the technique and statutory ban that the government has incurred on the technique. She is able to raise certain ethical arguments such as the right to choose the gender of the unborn child which is strictly against the principle of equality.

Overall, the three cases rely on the use of argumentation for transacting ethical issues in their classrooms. These arguments were raised either as an explanation for a social phenomenon listed in a statement form (e.g. Saju) or posed as an ethical question (e.g. Geeta and Ananta) inquiring into students' conceptions and beliefs.

In dealing with the ethical issues in Biological Sciences teachers' knowledge about ethical principles and role of Ethics contributes to their PCK with respect to ethical issues. The teachers in our sample may not be having a theoretical knowledge of ethical theories and principles but, a basic understanding about what is right and ought to be done and what is wrong and ought not to be done was evident from their responses. For instance when asked about the general understanding about ethics and its role in sciences, case 1, Saju responded as follows. "Since science and technology touch every aspect of human life, ethical issues are bound to arise. It is the inherent dual nature of the technology that has its pros and cons and decision about how, when and why the technology should be used that turns it into an ethical issue rather than a simple science and technology issue".

Thus, the above statement given by the teacher indicates that she is trying to link the role of ethics in science for taking decisions pertaining to the use and misuse of any technology, keeping in mind the consequences that the use of a particular technology can cause. Similarly, case 2 Geeta responded to the role of ethics in science in the following manner. "ETHICS provide us with a GUIDELINE to follow what is RIGHT as well as to distinguish between RIGHT and WRONG". "I agree that they should be aware about the consequences of each and every technology and should go for technology that is more environment friendly".

The above definition of 'ethics' provided by the teacher is somewhat normative in character and tends to divide the actions into the two categories of right or wrong. The role of ethics in science according to her comes into picture for guiding the students and people on the virtuous path which in the present case is adopting environment friendly technologies that pose least harm. Case 3, Ananta also holds a similar view about the role of ethics in science that can be presented as follows. "Technology is offering us so many advancements, before using them we need to find out the pros & cons, advantages & disadvantages, and whether it is going against ethics?".

Again the role of ethics that is being conveyed comes in deciding about a particular technology by weighing its pros and cons. This also represents a method of ethical enquiry and decision-making when there are conflicting evidence available then in that case the alternative which has maximum advantages or least harm is preferred over others (Principle of Beneficence & Principle of Non-Maleficence).

It was found that all the three cases took recourse to *Consequentialist* and *Deontological ethical theories* most of the times for backing their arguments and claims with respect to ethical issues in Biology (Table 4, 5 & 6).

The arguments have been analysed using the ethical framework developed for the present study. For instance, Saju regarded the misuse of the technology of Amniocentesis immensely detrimental for the female population when she said, "At many places in this country the technique has been misused in detecting the sex of the unborn child leading to aborting of the female foetuses" (Consequentialist argument, Table 4).

Geeta seemed to be worried about the increasing population and limited resources and advocated the use of contraceptives in order to avert misery and pain. "Every sixth person in the world is an Indian. Is it good? What could be its impact? This will directly affect the economic development of the nation as a whole and drive our nation towards poverty, unemployment, and all those social evils that we had overcome in the recent past" (Consequentialist argument, Table 5).

In order to stress on the duties and responsibilities of the parents, Geeta adopted a 'rights' approach and commented, "Do parents have any right to determine the sex of the unborn baby?" (Deontological argument, Table 5).

Ananta is a great supporter of technology as according to her every technology is for the benefit of mankind. This was evident when she said, "There is no harm in using this technology if it can provide them with a baby" (Utilitarian argument, Table 6).

She also adopts a deontological approach when it comes to the rights of a female child and discrimination against them in society. "Should the couples have the right to decide whether to have a girl child or a boy child?" (Deontological argument, Table 6). Thus, teachers' conceptions of ethics plays an important role in building their understanding vis-à-vis ethical issues related to Biological Sciences and also their PCK in the context of ethical issues.

Table 4

Analysis of arguments made by the case I, Saju

ETHICAL THEORIES	CONSEQUENTIALIST/ UTILITARIAN	DEONTOLOGICAL/ RIGHTS APPROACH	VIRTUE	ETHIC OF CARE
Topic I: Amniocentesis	At many places in this country the technique has been misused in detecting the sex of the unborn child leading to aborting of the female foetuses.		Elders should not hesitate in discussing issues related to reproductive health with their children rather should be given the correct knowledge about all these aspects.	
Topic 2: Contraceptives	An ideal contraceptive is one which is user friendly, effective, and with least side effects. Now it is high time that we start controlling our population.			
Topic 3: GM Crops	Natural methods of crop improvement and growth are being used. Then the product that will be obtained is environment friendly. It will not have any adverse effect on the people consuming such crops. However, we don't know much about the limitations of organic farming, including ability to increase the crop productivity only to a certain extent.			
Topic4: GMOs	They are useful, definitely as they are benefitting mankind, for instance, production of insulin in large quantity. If by genetic modification some harmful gene is introduced into the crop, which can affect a large population, then definitely such a technology can become harmful even more disastrous than nuclear bomb.	Continuous monitoring is required to keep a check on such practices.		
Topic 5: HGP	It can lead to selecting a particular trait in a human being which can adversely impact the natural evolutionary process.	Privacy needs to be maintained and such information should not be publicised. Demeaning the right to life of other organisms who don't have such a selective repertoire of genes.		

TABLE 5

Analysis of arguments made by case 2, Geeta in the class room

ETHICAL THEORIES	CONSEQUENTIALIST/ UTILITARIAN	DEONTOLOGICAL/ RIGHTS APPROACH	VIRTUE	ETHIC OF CARE
Topic I: Amniocentesis	Medical technology as 'Amniocentesis' is promoting this female foeticide. If done for positive reasons, then yes amniocentesis should be done as it helps in identifying many congenital diseases.	Do parents have any right to determine the sex of the unborn baby? Why are males given so much preference and females regarded as a fairer sex? "Amniocentesis should not be used for sex determination".		
Topic 2: Contraceptives	"Every sixth person in the world is an Indian. Is it good? What could be its impact?". This will directly affect the economic development of the nation as a whole and drive our nation towards poverty, unemployment, and all those social evils that we had overcome in the recent past. Repeated usage can cause irregular menstruation, excessive bleeding, mood swings and tender bones.	If a family is not in a position to support another individual in the family then what will such a potential human being do in poverty where even there are no basic amenities available.		
Topic 3: IVF	It's like a boon to childless couples.	I think that at the single cell stage it has no life, here comes philosophy, you have to define where life is?		

Table 6

Analysis of arguments made by case 3, Ananta

ETHICAL THEORIES	CONSEQUENTIALIST/ UTILITARIAN	DEONTOLOGICAL/ RIGHTS APPROACH	VIRTUE	ETHIC OF CARE
Topic 1: Amniocentesis	If we ban the technique then all the benefits that such a technique has to offer are also removed. Then what is the use of banning such a technique that has a good positive effect also.	Sex-determination is punishable by law, but still it does not deter the people from practicing it. Should the couples have the right to decide whether to have a girl child or a boy child?	Sex-determination is punishable by law, but still it does not deter the people from practicing it.	
Topic 2: Contraceptives	"Contraceptives HAVE to be used as there is population explosion, which is the root cause of all the problems".	"Yes, some contraceptives could be abortifacient and they should not be used, for example Cu-T will only prevent implantation, fertilization can still occur".		
Topic 3: IVF	"There is no harm in using this technology if it can provide them with a baby; the only thing is nothing should be exploited beyond its limits".			
Topic 4: GM crops	"If we talk about GM Cotton then there is no harm in its cultivation as nobody is going to eat it, but if we talk about Bt-Brinjal, yes even I won't like to eat because you never know what thing it is going to cause".			
Topic 5: HGP	"That will help us detect diseases easily, and can treat them in a better manner. Now-a-days, doctors do give drugs but many-a-times it is a hit and trial method that they adopt. But, if our genome is available then specific drugs can be given".			

Results about RQ2: structural quality of teachers' arguments

The quality of teachers' arguments varies across different teachers. The argument analysis using Toulmin's Model revealed different levels of argumentation among teachers based on the scoring rubric (Table 3). The arguments were analysed for the presence of data, claim, warrant, backing, qualifier and rebuttal (Table 7, 8 & 9).

TABLE 7

Argument analysis of Saju's Arguments using Toulmin's Method (Average Score = 3)

S. No	ARGUMENT TOPIC	DATA	WARRANT	QUALIFIER	BACKING	REBUTTAL	CLAIM
1.	**Amniocentesis (LEVEL= 4)**	At many places in this country the technique has been misused in detecting the sex of the unborn child leading to aborting of the female foetuses.	Girls are considered as burden on their families. There is a gender bias in our society, so that is the main cause behind it.		Principle of Gender Equality	It is a technique to determine the chromosome number and pattern or any kind of genetic defect.	The technique is being misused for sex determination especially in India.
2.	**Contraception (LEVEL= 3)**	Now it is high time that we start controlling our population.			Consequentialist	I do feel that it is controlling a natural process.	I think it is wise to use contraceptives.
3.	**IVF (LEVEL= 2)**	In some countries IVF is banned. When only one of the partners is the biological. parent to the child which leads to estranged relationships.	This technique can be commercialised for making money by the medical professionals.		Consequentialist	And the people who want their genetically own child say that this is because their own child will take care of them in old age.	It is always better to adopt the child.
4.	**GM Crops (LEVEL= 4)**	The growing of genetically modified varieties of crop plants can lead toward the development of certain resistant varieties of pests and super weeds whose effects can be difficult to counter act once introduced into the environment.	The environmental impact of such genetically modified organisms cannot be foreseen and we cannot predict the kind of effect it has on future.		Consequentialist	With a country like India with huge population size, whether organic farming will be able to fulfil the needs of growing population.	I am for organic farming, naturally occurring plants which are crossed naturally.
5.	**HGP (LEVEL= 2)**	It can lead to selecting a particular trait in a human being.	It is like completely opening up your inner self to the outer world.		Privacy needs to be maintained and such information should not be publicised. Everybody has a right to live even if he/she does not possess those superior selective genes.		i) This is actually in a way making a person completely naked. ii) Can adversely impact the natural evolutionary process.

Table 8

Argument analysis of Geeta's arguments using Toulmin's Method (Average Score = 4)

S. No	ARGUMENT TOPIC	DATA	WARRANT	QUALIFIER	BACKING	REBUTTAL	CLAIM
1.	**Amniocentesis (LEVEL= 3)**	People have a craving for a male child because he is the ultimate possessor and heir of the family's name.			Deontological	Amniocentesis should be done as it helps in identifying many congenital diseases.	Amniocentesis should not be used for sex determination.
2.	**Contraception (LEVEL= 5)**	Every sixth person in the world is an Indian. China follows a one child norm. Large population size contracts epidemics such as dengue, malaria, etc.	Rising population will directly affect the economic development of the nation as a whole.	If a family is not in a position to support another individual in the family.	Consequentialist	Repeated usage of contraceptives can cause irregular menstruation, excessive bleeding, mood swings and tender bones. These kinds of pills also encourage pre-marital sexual relationships.	Population needs to be controlled for creating a balanced and well developed society.
3.	**In-vitro Fertilization (LEVEL= 3)**	In-vitro fertilization and Surrogacy has now taken the shape of a booming industry.	At the single cell stage it has no life.	If both the parents are okay and just the fertilization is being done in-vitro then it is fine.	Utilitarian	Is it fair to reduce human beings to a machinery of producing children?	It's like a boon to childless couples.
4.	**GM Crops (LEVEL= 4)**	Genetically modified banana could cure diarrhoea in children and then vitamin A enriched rice. In Andhra Pradesh the Government fell because of this Bt-cotton and also led to huge number of farmer suicides.	Although testing is being done, but how we don't know. I don't think that a common man would even be able to afford GM crops at such exorbitant prices. bacterial toxin affect the human system and some microbes in our body might take up that toxin to develop antibiotic resistance.		Consequentialist	May be pest resistance could be one of the reasons for the introduction of GM technology.	GM crop is not for a country like India where there is mass scale corruption. Bt-cotton I don't think it is successful.

S. No	ARGUMENT TOPIC	DATA	WARRANT	QUALIFIER	BACKING	REBUTTAL	CLAIM
5.	**HGP (LEVEL= 5)**	Insulin can also be synthesized.	Most of the metabolic disorders can be treated by using gene therapy once you the sequence of genes that is responsible for producing particular enzymes.		There needs to be stricter control and regulation only then can the technique be really useful (Deontological/ Rights approach).	Once the tool is in the hands of miscreants it can result in biological warfare, or certain organisms can be specifically created which can say attack humans leading to mass destruction.	Emphasis I think should be more on how this human genomic project can be used to cure diseases.

An average score for each of the cases was calculated as per which Geeta scored highest followed by Saju and Ananta. This shows that Geeta has a better understanding and knowledge of argumentation (KArg) with respect to ethical issues in Biological Sciences as compared to the other two cases. Geeta's arguments are complete in the sense that they comprise of all the six components of a 'good' argument. According to Erduran et al. (2004), the arguments having a valid rebuttal are rated higher as compared to the ones with no or invalid rebuttal. Thus, Geeta's arguments happen to be less ambiguous as the claim and rebuttal can be clearly differentiated which is not the same with other cases. In the case of the other two teachers, there are weaker claims with few to none rebuttals which indicate a faulty or inadequate understanding of the issues. The Toulmin-Erduran argument analysis revealed many different facets of teachers' knowledge about ethical issues such as the ethical theories upon which they based most of their arguments, and their subject matter knowledge evident in the data, claims, warrants, qualifiers and rebuttals present in their arguments. The argument analysis can be taken as a basis for improving upon the present understanding about ethical issues among teachers. Argument analysis can serve as a basis for diagnosing various myths and fallacies that even some veteran teachers may be carrying with them and hence a route for their eradication and correction. In the present study, argument analysis revealed an insufficient knowledge structure of the teachers in the area of ethical issues in Biological Sciences, for instance, teachers Saju, Geeta and Ananta could not provide valid qualifiers, warrants and rebuttals in some topics. Thus, an awareness about these ethical issues needs to be generated among the teachers along with a sensitivity component so as to arrive at complete and well grounded arguments.

Table 9

Argument Analysis of Ananta's Arguments using Toulmin's method (Average Score = 2.2)

S. No	ARGUMENT TOPIC	DATA	WARRANT	QUALIFIER	BACKING	REBUTTAL	CLAIM
I.	**Amniocentesis (LEVEL= 2)**	If we ban the technique then all the benefits that such a technique has to offer are also removed. More of rural population than urban is misusing this technology, especially in parts of Punjab and Haryana. Sex-determination is punishable by law, but still it does not deter the people from practicing it.			Utilitarian theory and principle of Beneficence		What is the use of banning such a technique that has a good positive effect also.
2.	**Contraception (LEVEL= 3)**	Burgeoning population size and the present situation of the country. So many limiting factors, in terms of material resources, job opportunities, education, and other medical facilities required for basic human survival.	There is population explosion, which is the root cause of all the problems.		Consequentialist	Yes, some contraceptives could be abortifacient and they should not be used, for example Cu-T will only prevent. implantation, fertilization can still occur.	Contra-ceptives HAVE to be used.
3.	**In-Vitro Fertilization (LEVEL= 2)**	IVF is helping so many couples so if some embryos are being wasted then we have to bear with it, you know every rose has a thorn".	As it is every month an egg is being wasted during menstruation, even in an ejaculate there are millions of sperms, out of which only one fertilises, so here again there is a wastage of sperms. We have to be somewhat liberal, we cannot think on these grounds.	The only thing is nothing should be exploited beyond its limits.	Utilitarian		There is no harm in using this technology if it can provide them with a baby.

S. No	ARGUMENT TOPIC	DATA	WARRANT	QUALIFIER	BACKING	REBUTTAL	CLAIM
4.	**GM Crops (LEVEL=3)**	It is a win-win situation for farmers as once they buy Bt-cotton seeds from the market, later they can grow their own Bt-seeds.	Alternative is that is being practiced by people in America who now grow one row of Bt-cotton and one row of normal cotton. Such a practice helps in preventing resistance amongst boll worms"	if we talk about Bt-Brinjal, yes even I won't like to eat because you never know what thing it is going to cause.	Principle of beneficence & non-maleficence	If we use Bt-cotton for a long time it may create resistance in boll worms.	If we talk about GM Cotton then there is no harm in its cultivation as nobody is going to eat it.
5.	**HGP (LEVEL= I)**	Now-a-days, doctors do give drugs but many-a-times it is a hit and trial method that they adopt.	I don't think that we are anywhere loosing the privacy. And that will help us detect diseases easily, and can treat them in a better manner.		Principle of beneficence Utilitarian		If our genome is available then specific drugs can be given.

Discussion

The present study revealed different facets about teachers' PCK with respect to ethical issues in Biological Sciences. As was observed in some of the classrooms, the teachers usually took recourse to 'Argumentation' as a chief method for introducing and explaining the ethical issues to their students. Thus, knowledge and skill of argumentation formed the major component of senior secondary Biology teachers' PCK with respect to ethical issues in Biological Sciences. In science, argumentation plays a chief role in advancement of knowledge and validation of claims, conclusions and explanations (Sampson & Clark, 2009, 2011). However, the Toulmin's method of argument analysis revealed that the nature, content and quality of arguments offered by our three case respondents varied largely making their PCK idiosyncratic and unique in their own ways. It was often noticed that teachers' arguments with respect to ethical issues are not based on some scientific data or research rather on their inherent beliefs and notions about a particular technology mostly derived from media reports,

newspaper and their own experiences. There was least mention about nature of science and philosophy of science principles such as universality, falsification, subjectivity, etc in teachers' arguments. The arguments when coded for the ethical theories revealed that they are based on certain inherent ethical assumptions (mainly consequential and deontological) but in an implicit way rather than an explicit one. Thus, teachers' hidden notions about ethics does impact their argumentation and understanding about ethical issues. The quality of their arguments came out to be average indicating a weak argument which could be due to inadequate understanding of ethical issues. Thus, teachers lack competency in the area of addressing ethical issues in the classroom which may indicate poor PCK-components like 'KET'.

Teachers blame it to the present structure of the curriculum and textbooks that gives little space as well as recognition to these issues, as was evident when one of the cases said, "No, these ethical issues are not given their due importance and do not occupy much of the space in the text-book. And since these are not being addressed in the text-book adequately therefore their treatment at the transaction level is also very fleeting. Had they been taken care in the text-book or mentioned in the curricular guidelines then surely their treatment and importance would have been very different" (post-observation interview, case 2 Geeta).

Thus, the problem of addressing these ethical issues in the classroom is not just the matter of the teachers' limited PCK, rather the larger regulatory framework including government, its policies and National Curricular Framework that determine the curriculum that is to be practiced at the high school level. Applying the Bernstein's idea of recontextualisation of knowledge, where the teachers' beliefs and methods of teaching that they adopt in order to transact and transmit the knowledge belong to the pedagogic recontextualising field (PRF), whereas the state structures, policies, selected agents and ministries that frame the rules and develop the curriculum belong to the official recontextualising field (ORF). The actual 'pedagogic discourse' (Bernstein, 1986, 1990) that is happening in the classrooms is actually the result of the interaction of these two fields, which also means to say that if PRF has a greater influence over the pedagogic discourse as compared to ORF, then it establishes the autonomy and struggle of the teacher (Bernstein, 2000, p. 33). Since, the teachers in our present study are bound by the curriculum, therefore they are not able to establish their autonomy vis-à-vis the content that is to be transmitted, and hence the pedagogic discourse (Bernstein, 1986, 1990) is largely determined by the ORF than PRF. This can be taken as one of the major reasons that ethical issues are not coming out explicitly and elaborately in the classroom interactions but valuable arguments are generated during in-depth interview sessions.

Implications For Education

'The present study aimed at understanding the components of PCK that impact teachers' arguments with respect to ethical issues in Biological Sciences, as well as the structural quality of such arguments'. The findings revealed that the major component of science teachers' PCK that were found helpful in transacting the ethical issues effectively in the classroom is their knowledge of argumentation and initiating discussions around the topics of ethical relevance. As is also shown by Levinson (2003) argumentation has been highly accorded as a means for the appropriate transaction of such issues of ethical relevance. Moreover argumentation as a classroom practice is said to promote student learning (Newton, Driver & Osborne, 1999). The implication of this finding is that teachers need to be much more aware and cognizant about the value and method of scientific argumentation and should understand its importance. This could be a part of their pre-service teacher education programme.

Learning has always been a pre-requisite for teaching, and a PCK can be effective only if it brings about desired learning outcomes. Teachers in the present study seem to initiate some thinking in this direction, however they lack serious planning and assessment of students' ethical understanding in this respect. The implication of this could be that teachers need to concretise the knowledge pertaining to these ethical issues so as to make the students understand them better and also in enabling them to take decisions vis-à-vis any technology at hand. This can be done by way of designing some problem-solving exercises for students involving some or the other sort of ethical dilemma, narrating case studies to them and then raising some ethical questions, or contrived and simulation activities raising some ethical concerns for the students to connect by contextualising the content taught in the class. One of the findings of our study also revealed that the 'KET-component' of PCK affected teachers' arguments about ethical issues. Teachers' arguments relied implicitly on two ethical theories, viz., consequentialist and deontological theory. However, they did not mention about any of these theories explicitly.

Therefore, if given an opportunity to learn and practice the various frameworks of ethical enquiry would enable them in better argument generation, reaching a balanced perspective simultaneously, building their own understanding about the different points of view presented by other frameworks. Thus, a discussion and deliberation on the various ethical theories should become a part of the pre-service and in-service teacher education programmes. This will not only familiarise these teachers about the ethical theories but also seek the relevance of ethics in science and the areas of confluence of both the disciplines to inform, liberate, empower and sustain the bridges between humanity and the other world including fellow beings, animal world, the inanimate and the encompassing environment. Finally, our conceptualisation of PCK with regard to ethical issues in Biological Sciences stresses upon the pre-dominant role of knowledge of argumentation (KArg) and knowledge about Ethics (KET) as the major variables

of teachers' knowledge that determine the manner in which these issues are dealt in the classroom. Thus, the claim the present study makes is that PCK with respect to ethical issues in Biological Sciences can be enriched if KArg and KET is augmented and informed regularly. This would require the congruent efforts of not just the teachers who are working at the grass root level but also the curriculum developers, text book writers, policy makers and heads of the institutions of learning to collaborate for redesigning the curriculum in the light of ethical issues in biological sciences.

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