Res Sci Educ (2019) 49:109–136
DOI 10.1007/s11165-017-9612-8

Teachers' Perceptions of Infusion of Values in Science Lessons: a Qualitative Study

Jayanthy Kumarassamy[1] · **Caroline Koh**[1]

Published online: 23 June 2017

Abstract Much has been written and debated on the importance of including moral, character or values education in school curricula. In line with this, teachers' views with regard to values education have often been sought. However, a search into the literature on values in science education has revealed little on this domain. In an attempt to close this gap, this study explored the views of teachers with regard to values infusion in the teaching of science. The aim was to investigate teachers' perceptions on two broad areas: (i) how values were infused or addressed in lower secondary science and (ii) how values-infused science lessons influenced their students' dispositions and actions. The participants who took part in the interviews were lower secondary science teachers teaching Grade 8 in selected Singapore and New Delhi schools. The findings showed that values inherent in the discipline of science, such as validity, fairness, honesty, rigour, predominated in the lessons conducted by the teachers in both contexts. Furthermore, in Singapore, equal numbers of teachers made references to values upheld and practised by scientists and values arising from the interplay between people and scientific processes and products. In New Delhi however, the emphasis was higher on the latter category of values than on the former. Generally, in both contexts, values infusion in science lessons was not planned but occurred spontaneously as values issues surfaced in class. Teachers in both Singapore and New Delhi used strategies such as questioning, discussion, activities and direct instructions to carry out values infusion, although they experienced challenges that included content and time constraints, lack of student readiness and of teacher competency. Nevertheless, the teachers interviewed perceived that values in science lessons brought about changes in students' personal attributes, affect and behaviour, such as greater interest and prosocial engagement.

✉ Caroline Koh
caroline.koh@nie.edu.sg

Jayanthy Kumarassamy
JAYANTHY001@e.ntu.edu.sg

[1] National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore

Keywords Values infusion · Science teaching · Teacher perceptions

Introduction

The importance of including moral, character or values education in school curricula has been the subject of much discussion. In a study involving public school administrators, Wood (1999, p.8) found that the participants were in favour of values being taught in schools because "many students receive none at home". Likewise, the findings of Jacobs and Reetz (1999, p. 209) revealed that teacher education faculty perceived that it was "important for college professors to address moral and character issues with their students". This view was also upheld by pre-service teachers, who felt that including character education in a curriculum/methods course was important (Beachum et al. 2013). Sutrop (2015, p.189) proposed that the notion of a value-free education is a fallacy, since "values permeate every aspect of education", and hence the need for more emphasis on preparing teachers for their tasks as values educators. These views are echoed in a study conducted in Turkey to examine teachers' perceptions of moral education (Temlı et al. 2011). In Saudi Arabia, Musa and Khawaldah (2007) found that the teacher participants complied with social values in their teaching but did not discuss or address moral issues in class, a trend that seems to be observed in most other related studies.

The scenario, however, may be quite different in Asian contexts, where collectivist cultures have long established value systems in support of the common good. In such cultures, the common goals of a collective group or in-group takes precedence over the goals of the individual, and in the words of Triandis and his colleagues, "much of the behaviour of individuals may concern goals that are consistent with the goals of this ingroup" (Triandis et al. 1988, p. 324). In India, for instance, the general view is that the family and the community play a predominant role in fostering moral conduct and values. The schools thus adopt an informal approach to values education, with teachers setting good examples, role-modelling desirable attributes and building a harmonious environment (Sharma and Mohite 2007). Yet, if teachers are to mediate values transmission, how do they respond to the task? What approaches do they adopt and in what ways do they engage students in the values discourse?

Rationale and Purpose

Bryan and Atwater (2002, p.822) posit that "the process of learning to teach begins with making explicit one's beliefs about teaching and learning", and that "beliefs describe the structure and content of a person's thinking that are presumed to drive his/her actions." Furthermore, the literature shows that teachers' thinking and beliefs have significant influence on their purposes, decision-making and other aspects of their work, such as lesson preparation and assessment (Nespor 1987; Pajares 1992; Richardson 1996; Taylor 1990). One can therefore surmise that teacher perceptions and beliefs on values would influence their contribution to values education in class.

Though much is known about teachers' perceptions with regard to values education in general, there is a dearth of knowledge in the extant literature on teachers' perceptions of values in science education. The purpose of this research is to better understand teachers' perceptions on values infusion in the teaching of science, firstly in terms of the ways and approaches undertaken and challenges encountered in the process and secondly the impact, if any, on students' dispositions and behaviour.

Values in Science—Theoretical Underpinnings

The current study uses Albert Bandura's Social Cognitive Theory (Bandura 1989, 2002) as a basis for understanding teachers' perceptions on values infusion. In addition, Allchin (1998, 1999) offers a framework that outlines existing approaches and/or initiatives in science and how they may be infused in science teaching in the classroom.

Bandura's Social Cognitive Theory Bandura (1989, 2002) claimed that individuals acquire knowledge and learn from others through observations, social interactions, experiences and modelling. The theory posits that there is an agentic element to human development and functioning, whereby the *agent* exerts an intentional influence on the individual. In the context of this study, the teacher serves as an agent for values infusion, exerting influence over his/her students who learn from him/her (and influential others) through observation, interaction and modelling. Bandura (2002) outlined three modes of agency: direct personal agency, proxy agency and collective agency. In direct personal agency, the individual uses his/her own influence to secure his/her desired outcomes. Proxy agency involves the individual making attempts to secure the desired outcomes through the mediation of the more influential or powerful others. In collective agency, individuals achieve a common goal through pooling together of their resources. This study aims at investigating the views of teachers who, as agents of influence, interact with and provide models for their students and in doing so, affect the latter's values outlook and disposition. The teachers' perceptions would also shed light on the mode of agency used by teachers in the infusion of values.

Allchin's Framework for Approaches to Values Infusion A number of authors have discussed how values infusion could be implemented in the classroom through the consideration of socio-scientific issues or controversial issues. They also advanced arguments against traditional school science and highlighted the advantages of infusing values in science (Aikenhead 2007; Hodson 2003). However, for the purpose of the current study, Allchin (1998, 1999) offers a framework that outlines existing approaches and/or initiatives in science and how they may be infused in science teaching in the classroom. In his model, Allchin envisioned values as intersecting with science in three major domains, denoted as categories A, B and C in this study. Figure 1 shows what these categories entail.

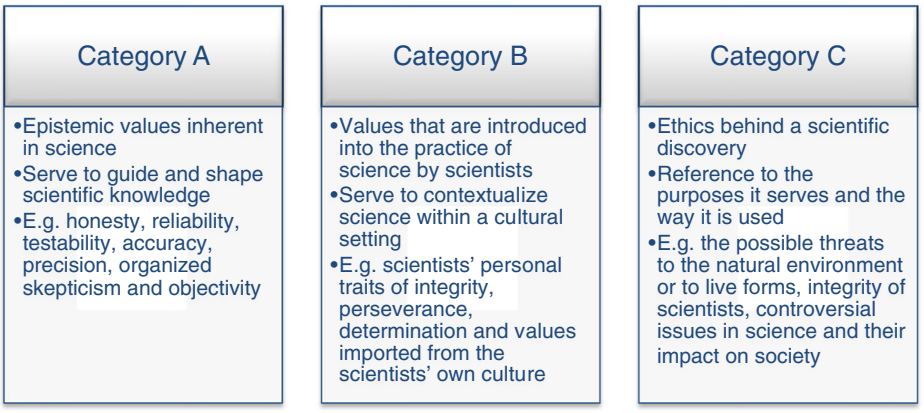

Fig. 1 Allchin's categories of values

In this study, Allchin's framework, in conjunction with Hildebrand's (2007, pp. 52-53) list of epistemic values were used for the identification and categorization of values in science. Allchin's framework (Allchin 1998, 1999) was chosen as it offered a clear and distinct view of what values in school science entails in practice. Allchin (1998, 1999) presented a comprehensive view about how values intersected with science in three distinguishable ways. Particularly, in this study, Allchin's (Allchin 1998, p. 1083) description of values in science could inform, firstly, whether teachers' perceptions of values were in line with what values mean in scholastic literature, and secondly, whether teachers alluded to all three ways in which, according to Allchin (1999), values intersect with science. This provided the theoretical basis for the current investigation on the perceptions of lower secondary science teachers on the infusion of values in science lessons in Singapore and New Delhi.

The research in the current study was driven by two questions, aimed at investigating teachers' perceptions on the following:

1. *How are values infused and/or addressed in the teaching of lower secondary science in the participating schools in Singapore and New Delhi?*
2. *How do values-infused science lessons influence students' dispositions and actions in the participating schools in Singapore and New Delhi?*

The data collection aimed to provide insights into the following:

1. Teachers' understanding of the meaning of the term 'values in science' through their descriptions of values-infused science lesson segments.
2. Teachers' perceptions of how they planned for the infusion of values in their science lessons.
3. Teachers' perceptions of how they facilitated the infusion of values in science lessons.
4. Teachers' perceptions of challenges they face in infusing values in science lessons.

Method

Methodological Assumptions

The current study was based on the general characteristics and assumptions of qualitative research (Creswell 2012, 2014). For instance, the sample size of the participants was kept low and the participants were identified through purposeful sampling, with the aim of involving those who were in the best position to contribute to the central focus of the study, i.e. the understanding of teachers' perceptions of values infusion. This is based on the ontological assumption that multiple realities and perspectives were presented by participants, with the research being context-dependent and value-laden. The research outcome was therefore the subjective evidence gathered by the researcher based on the epistemological assumption that the latter was able to get as close as possible to the participants' realities. As such, data collection was carried out through general interviews with open-ended questions to elicit free sharing from the participants. The ensuing sections will give further details on the processes of data collection and analysis.

Participants

Ten secondary schools, five each from Singapore and New Delhi, accepted the invitation to take part in the research study. In each of the participating schools, the Heads of Department identified two teachers as participants for the study, with the exception of one Singapore school from which there was only one participating teacher. The teachers were selected on the basis of their embodiment of school ethos (typical sampling) and their age variation (maximal variation sampling). A total of 19 teachers agreed to participate in the study. The participants, 5 males and 14 females, who took part in the interviews were two groups of lower secondary science teachers, aged from 26 to 58 years, teaching Grade 8. One group consisted of nine Singapore teachers (five males, four females) with an age range of 28 to 41 years and the other group of ten New Delhi teachers (0 males, ten females) with an age range of 26 to 58 years. The teachers were from ten secondary schools, five from Singapore and five from New Delhi.

Justifications for Study Contexts

Singapore and New Delhi are two Asian cities into which science and school science were imported from another culture. In both countries, the British introduced education, aiming to produce an elite workforce for the civil service, while Science education was introduced to ensure enough operators for the mechanization that was taking place as a result of the industrial revolution in Europe. Particularly in New Delhi, the British introduced a scientific approach to education in a system permeated by local religious influence and a heavy emphasis on memorization of sacred texts and scriptures to facilitate learning (Forkner 2012). The colonial education system also contributed to the widening of the gap between the elite and the agrarian societies (Venkateswaran 2007). It was a case where colonialization took place without adequate understanding of the culture and indigenous systems of the colonized lands (Ryan 2008).

The cultural background of a person influences values (Paul et al. 2006). Both Singapore and New Delhi subscribe at large to what is known generically as *Asian values*. Asian values are typically and primarily shaped by the religions and philosophical outlooks of the different religions of Asia, such as Buddhism, Taoism, Confucianism, Hinduism and Islam (Cauquelin et al. 2000). It is to be noted that none of these religions or philosophies distinguish between religious values and secular values. The religious text contains guidelines for both worship and conduct in everyday life (Cauquelin et al. 2000). Besides religion and philosophy, factors such as history, economy with urbanization and industry, geographical and climatic conditions and calamities, both natural and man-made, shape a nation's value system. Globalization, defined broadly as, "the movement towards greater interaction, and interdependence among people and organizations across national borders" (Rondinelli and Cheema 2003) is another phenomenon that can influence value systems of a nation or a region. Globalization embraces economic, historical and social processes, which can eventually transform "spatial organization of social relations and transactions, generating transcontinental or interregional networks of interaction and the exercise of power" (Held and McGrew 2002). As such, although the social contexts of the Singaporean and New Delhi participants started off as different, there might be a closer rapprochement in their beliefs and cultural inclinations than one would have thought. This study sought to investigate the extent of this alignment with regard to the teachers' perceptions of the infusion of values in science education.

Interviews and Data Collection

The participants' consent was obtained for both the interviews and the audio recordings of their responses using an MP3 recording device. All teachers except three from New Delhi agreed to the audio recording. The responses of these three teachers were recorded manually and later entered into the databases created for compiling interview responses.

Semi-structured interviews were conducted with the participants on a one-on-one basis. Each interview began with a reference to the lesson that a particular participant had taught prior to the interview session. The interview was then built upon this initial reference, leading to a closer look at the teachers' perceptions of values infusion in science lessons and how this was carried out in the science classroom. The initial reference to the recent science lesson allowed the interviewee to revisit the stages of the lesson during which values, in the context of science, might have been mentioned. If no allusion to values was made in the last lesson, then the interviewee was asked to recall another lesson in which they made references to values. This helped to elicit from the teachers their perceptions of values infusion in science. A series of open-ended questions were used to guide the interview process, which centred on three areas:

- Teachers' deliberate use of methods and strategies for the infusion of values.
- Teachers' perceptions of the impact of these lessons on students.
- Teachers' perceptions of their experiences of teaching values-infused lessons.

The main questions are shown in Table 1.

Ensuring Trustworthiness

In qualitative research, trustworthiness of the study is ascertained by criteria such as credibility (validity), dependability (reliability) and confirmability (Creswell 2014, pp. 283–284; Hays and Singh 2012; Key 1997). There are several strategies that research suggests for establishing the trustworthiness of the study. These are through the examination of raw data, products of data reduction and process notes (Lincoln and Guba 1985), together with member checking, prolonged engagement in the field of study, persistent observation, triangulation, theory development, peer debriefing, simultaneous data collection and analysis and thick descriptions (Campbell 1996).

Table 1 Interview questions

Teachers' use of methods and strategies	Teachers' perceptions of the impact of these lessons on students	Teachers' perceptions of their experiences of teaching values infused lessons
1. What do you think about the lesson that was just over today? 2. What are your thoughts on whether you were able to address some values issues pertaining to the science topic being taught? 3. If yes, how was this achieved? 4. If no, why?	5. How would you rate the impact on students? Reasons?	6. What were your experiences in planning and preparing for this lesson? 7. What were the challenges? 8. How would you do the lesson differently if you were to repeat this lesson?

In the current research, member checking was conducted to enhance the credibility of the study. Lincoln and Guba (1985) define member checking as the testing of data, their interpretations and conclusions with the group stakeholders or stakeholders from whom data was collected. It establishes if the findings from the study were a reasonable representation of the participants' reality and experiences. This method has been considered to be one of the most significant methods for the establishment of credibility and dependability. In the current study, the interview transcripts and a written report containing the interpretation of the findings and conclusions drawn were forwarded to the participating teachers. They were asked to respond to the accuracy of the interpretations and the conclusions reached.

Besides member checking, peer debriefing was carried out between the investigators on a regular basis. A second coder, together with the researcher, coded samples of the interview data during the initial phase of the coding process. They held multiple meetings to discuss any disagreements on the identification and establishment of codes and themes until a consensus was reached on the actual codes, categories and themes to be used in the actual analysis.

Data Analysis

The data were subjected to both deductive and inductive thematic analyses (Valenzuela and Shrivastava 2008). In thematic analysis, patterns within the data are identified and reported, allowing the interpretation of various aspects of the research topic (Braun and Clarke 2006; Crabtree and Miller 1999; Fereday and Muir-Cochrane 2006; Kwong and Bartholomew 2011) and the illustration of important themes that characterize the phenomena, in this case, values in science lessons (Braun and Clarke 2006).

In the inductive approach to thematic analysis, "the themes identified are strongly linked to the data … not driven by the researcher's theoretical interest in the area..." (Joffee 2012, p. 209) while in the deductive approach, the thematic analysis is driven by the researcher's "theoretical" interest in the area (Braun and Clarke 2006, p. 83). In this study, for the purpose of the deductive part of the analysis, an a priori template of codes (the classification framework or code-manual) was constructed based on Allchin's categories of values (Allchin 1999).

Deductive Method Deductive thematic analysis (Braun and Clarke 2006, p. 84) was carried out to categorize the responses according to Allchin's description of values in science (Allchin 1998). The code manual was used firstly in the organization of the large quantity of interview data into a more manageable database by first identifying and collating related pieces of text, in this case, all texts making references to values in science (Crabtree and Miller 1999; Fereday and Muir-Cochrane 2006). Secondly, the code manual was used to search within the organized data for evidence of what the teachers perceived as values-infused segments of the lessons they conducted. These were descriptions on how teachers conducted values-infused science lessons in the classroom. If an interview segment made reference to values in science, and the nature of the value(s) was identified, the segment was then assigned to a value category (A, B or C) prescribed in the code manual in accordance to Allchin's framework (Allchin 1999), shown in Fig. 1. This process helped to identify authentic values-related responses made by teachers and to describe them according to how the values intersected with science.

Inductive Method The inductive method of thematic analysis was used to address the exploratory aspects of the research questions, such as teachers' perceptions of the ways in which they infused values in their science lessons, teachers' perceptions of the challenges that

they faced in infusing values in their science lessons and their perceptions of how values in science influenced their students. Codes and themes were inductively formed, whereby segments of texts were labelled in order to form descriptions and broad themes in the data, which could then be assessed meaningfully to understand the phenomenon studied (Crabtree and Miller 1999, p. 164).

The coding was carried out systematically in the manner described by Creswell (2014). The process involved the following steps:

1. The first step was getting a sense of the data through careful reading of the transcripts. As the reading progressed, initial ideas and notes were noted along the margin of the hard copies of transcripts.
2. The coding process was carried out on this document. Text segments of interest or meaning were identified and bracketed. Each of these segments was assigned a word or short phrase describing its meaning. Following the initial coding on the hard copies of the transcripts, the codes, themes and the corresponding data extracts were organized on a spreadsheet.
3. All the code words that were developed for the entire text were listed. These codes were grouped accordingly to any similarities between them. Redundant codes were isolated and discarded.
4. This list of codes was referred to in the coding of the next transcript and new codes that emerged were added. At this point, data supporting specific codes were encircled.
5. Themes were developed from groups of similar codes. Outliers, if any, were retained for consideration at a later phase of the analysis.

In addition, the data obtained from the thematic analysis was also subjected to basic statistical analysis (e.g. percentage of teachers with similar responses) to enable some generalization of the findings.

Results

The results of the analysis of the interview data are summarized in Figs. 2, 3, 4 and 5.

Appropriate excerpts from the participants' responses are included to illustrate the issues raised. The names of the participants have been replaced with pseudonyms to ensure confidentiality.

Research Question 1

How are values infused and/or addressed in the teaching of lower secondary science in the participating schools in Singapore and New Delhi?

The analysis described teachers' views of infusion of values in the science classrooms in terms of the following areas:

- Teachers' perception of their understanding of values in science.

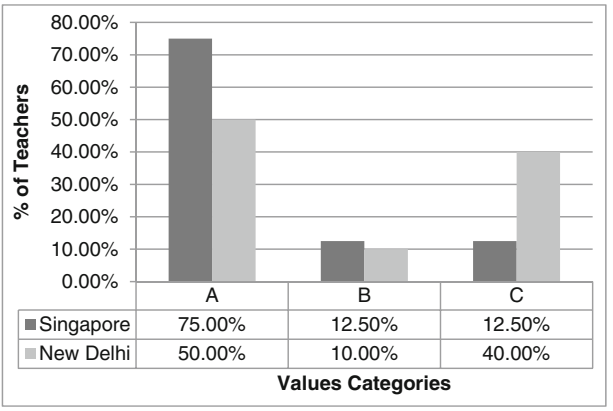

Fig. 2 Distribution of teachers' responses in the categories of values

- Teachers' perception of how they planned for the infusion of values in their science lessons.
- Teachers' perception of how they facilitated the infusion of values in science lessons.
- Teachers' perception of challenges they faced in infusing values in science lessons.

Teachers' Understanding of the Meaning of the Term 'Values in Science' A total of 18 relevant descriptions from teachers on values lessons *and their understanding of the meaning of values in science* were identified from both Singapore and New Delhi teachers in response to the questions:

Do you think you were able to address some values issues pertaining to the science topic being taught? If yes, how was this achieved? If no, why?

The teachers' understanding of values in science, according to their descriptions, was in agreement with the conceptualization of *values in science* gleaned from the literature, in particular Allchin's (1999) description of the three categories of values. The percentage distribution of responses in each of the three categories of values is shown in Fig. 2. It was found that for both Singapore and New Delhi, most of the identified responses were in category A, whereas category B obtained the lowest percentage. There was a significantly

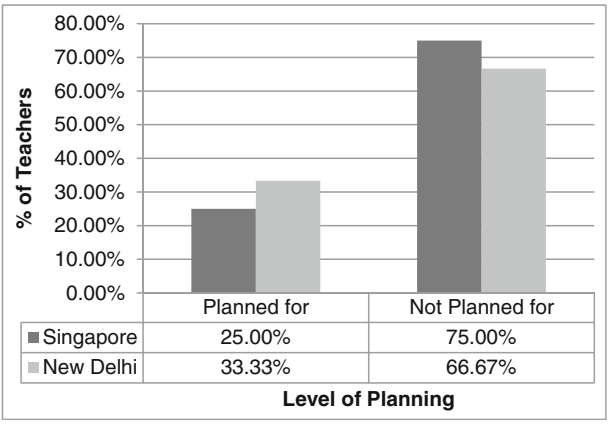

Fig. 3 Lesson planning—Singapore and New Delhi teachers

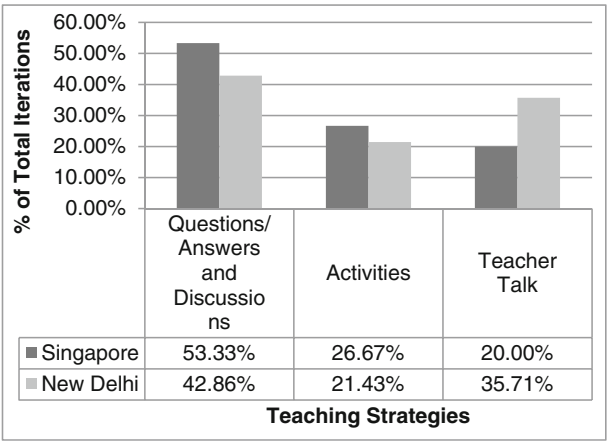

Fig. 4 Strategies used by teachers for values infusion—Singapore and Delhi

higher percentage of responses in category C for New Delhi than for Singapore while the converse is true for category A.

Singapore *Responsibility* and *open-mindedness* were some examples of epistemic (category A) values mentioned by Singapore teachers. One teacher raised the value of open-mindedness when he asked the students whether they agreed or disagreed with abortion. A majority of students indicated their disagreement. The teacher then told the students, "you ... need to open up also because there may be some reasons where maybe, it could be justifiable." Another teacher mentioned discussion of category B values in relation to a scientist and his/her traits, "when we do the introduction on scientific literacy and what a …yeah, just like Marie Curie or these scientists, what are their attributes/attitudes and other … perseverance and values, but for other topics, we do not really mention about scientists except for where we talk about ...okay, why is Newton unique and who is it named after and why is it important, all these things." A single response characterizing values of science emerging from its product and process (category C) referred to the impact of science and technology on the environment and conservation issues, "... you force the students to really observe things that are taking place around them and you talk about, you know physical chemical changes in relation to issues like conservation of environment... conservation of the environment was (a) very strong feature in

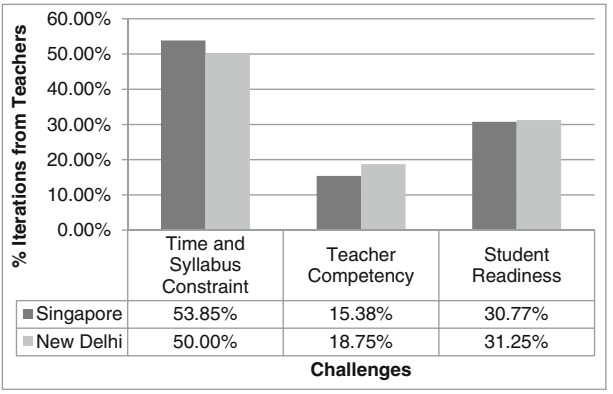

Fig. 5 Teachers' perception of challenges in infusing values in science lessons

… that topic and even when we talk about topics such as acids and alkaline… how acids are used as weapons, you know, in maybe societies where men don't treat women as well."

New Delhi With regard to category A, one of the teachers conducted a lesson on microorganisms and highlighted the part played by each organism in the ecosystem: "… respect all living creatures, all microorganisms are not harmful, some are useful, all needs to be respected, everything has its own importance…everything and everyone has its, his or her own importance." The importance of *care* was conveyed in another teacher's reference to natural disasters, and the need to take care of oneself and others, "…we could tell them how to take care of themselves, how to take care of others, when there is lightning or thunderstorms…or earthquakes…" *Conservation issues* and "effect of science and technology on man/society" related to category C values, such as in the mention of conservation, "For example, I say that in my home, we are not supposed to switch on the fan and light and move out of the room if I am not sitting in that room. I am supposed to switch it off."

Teachers' Perception of How they Planned for the Infusion of Values in their Science Lessons The interview question used to elicit answers to this part of the research question was:

What were your experiences in planning and preparing for values lesson?

A majority of the teachers interviewed (both in Singapore and New Delhi) did not plan for values infusion in their science lessons. Most of the time, values were addressed incidentally, as issues arose or as questions were asked, or as it occurred to the teacher on the spur of the moment (see Fig. 3f). Out of 19 teachers, four teachers undertook some kind of planning for their value lessons (see Fig. 3).

Singapore Reference to values in science lessons was mostly incidental. A teacher who held a discussion on premarital sex and its consequences, mentioned, "it was more like impromptu … because like in the morning when I saw the newspaper article, I thought it would be good to (include)."

Two teachers indicated that they planned for values in science lessons since science was part of the students' life and should add value to it, "I make it a point to always ask myself … what do they take away other than the science knowledge because at the end of the day, not everybody would end up as a science student. .So, what kind of value I'm I trying to inculcate, what real life understanding am I trying to bring to them so that it will stay with them? So, these are the thoughts … usually, when I will prepare a lesson."

New Delhi According to one teacher, experience gave her confidence: "Yes, while doing it, I don't have to plan all these because I have been teaching on the spot …you know… mutation, Japan; they are related with the world war and what are the changes, … it is not planned in my lesson but as and when, I… yeah…I do that."

Two of the teachers who planned for infusion of values in their lessons used the 2011 Fukushima nuclear disaster as a case-based scenario for incorporating values in Grade 8 science lessons. In order for other teachers to have at least a basic understanding of nuclear reactions, the interviewee prepared and shared a PowerPoint presentation that included an introduction to atomic structure. For values infusion, the teachers decided to include discussions on the pros and cons of nuclear reactors. In another instance, the teacher planned ahead

for outdoor activities for the lesson on crop production and management, "Generally I plan like, … I will take them out in the field and then I will show them; we have a compost pit, I will show them and then I will take them to nursery and show them cross planting. They take a lot of interest and even out of the class, they will come and they will talk about things."

Teachers' Perceptions of How they Facilitated the Infusion of Values in Science Lessons The following interview question elicited answers that addressed teachers' facilitation of values infusion:

> Do you think you were able to address some values issues pertaining to the science topic being taught? If yes, how was this achieved?

Teachers from both Singapore and New Delhi perceived that they addressed values in science lessons using four main teaching strategies, namely (1) activities (practical, group work, projects, fieldwork), (2) questioning and class discussions and (3) teacher talk. Fig. 4 illustrates the use of these strategies in the schools from Singapore and New Delhi. It shows that the Singapore teachers predominantly used activities (35.71%), and questioning and discussion (35.71%) for infusing values in their lessons, whereas in New Delhi, the teachers' most often used questioning and class discussions (42.86%) and teacher talk (35.71%).

Questioning and Discussion The predominant strategy employed by teachers in both Singapore and New Delhi classrooms, is questioning and discussion. These were used alternatively while engaging students in values discourse. Singapore teachers favoured open discussions on issues that served to enhance students' engagement with epistemic values in science, while New Delhi teachers used discussions to engage students in controversial issues in Indian society.

Singapore Iterations (53.33%) made reference to the use of questioning and discussion as strategies to elicit students to express their views (see Fig. 4). Questions were used to open discussions where divergent views were expressed, such as in the case of abortion and gastric banding. This is to elicit students' engagement with their own value systems and their assessment of a situation with open-mindedness, mindful of the many angles to a problem. One of the teachers explained, "… I feel that there is a lot of issues where [it] is better that we open up for discussion rather than telling them what to do." Yet, another teacher left it to the students to come up with some conclusions on gastric banding after he initially started them off with questions, "… I gave them…the scenario like is it a good thing or bad thing … why should this be adopted? Why should we intertwine using surgeries that (are) invasive? Why can't the person have a normal diet? … I won't tell them it's a bad thing to have gastric banding ... because some people seriously need…help in this matter so I just explain to them what it does and from there they will explore."

New Delhi Iterations (42.86%) (see Fig. 4) referred to questioning and discussions as a strategy used to discuss the pros and cons of an issue, for example, nuclear reaction. Mostly, these classroom discussions were prompted by many questions posed to the students. One teacher was passionate about discussing controversial issues with her students, "Somewhere I was reading about mercy killing…whether it is in the cell or not, whether it should be allowed or not allowed. Why is it not allowed in India? A topic like that is what I would like to co-relate with, (in) my lessons." During a discussion session on calamities and solutions for

people affected, the teacher discovered how a question on problem solving initiated a series of solutions: "when you collectively list down on the board there will be so many solutions … how can they help the people and all. So that will just initiate … the responses come out from them." Yet, another teacher discussed the hard work of local farmers to increase students' awareness and appreciation.

Activities Both the Singapore and New Delhi teachers used activities to engage students in values lessons. However, Singapore teachers predominantly used activities as compared to their New Delhi counter parts. New Delhi teachers used questioning and class discussions predominantly, followed by teacher talk and lastly activities. Singapore teachers carried out activities like group work and practical sessions. However, in Singapore, these activities tended to be classroom based whereas the few mentions from New Delhi teachers referred to outdoor fieldwork.

Singapore Iterations (26.67%) referred to activities as a platform for addressing values in science (see Fig. 4). In particular, practical sessions in the laboratory facilitated values discussion in two ways. Firstly, they provided a platform on which to highlight values issues, since it was in the course of activities and engagement that the teacher was able to perceive students' thoughts and address relevant issues within context, "… it's through hands-on activities that you can really see students, I mean, their internal states and…from there address things together…The students will be able to relate to it much better…something happening in the local context and it's something that the students see as relevant to them..." Secondly, practical sessions broadened students' experiences through a hands-on approach and enabled them to discover things they were unaware of. For instance, one teacher held a laboratory-based experiment to show how promiscuity increases the propagation of sexually transmitted diseases. According to him, it was more effective to show the effects of a certain phenomenon and to leave the students to draw their own conclusions.

New Delhi Iterations (21.43%) referred to activities to convey values messages (see Fig. 4). Two teachers mentioned fieldwork, one a tree-planting activity as part of a lesson on conservation, and the other, a trip to the school's vegetable plot. While the tree planting activity motivated students to carry out conservation activities on their own initiative, the visit to vegetable plots allowed them to experience farm life and to be aware of farming methods. For instance, one teacher said, "I will take them out in the field and then I will show them; we have a compost pit, I will show them and then I will take them to nursery and show them cross planting." Markedly absent was the mention of activities in the science laboratory.

Teacher Talk Both the Singapore and New Delhi teachers used teacher talk for the infusion of values in their lessons. However, it was more prevalent in New Delhi (ranking after questioning and discussions) than in Singapore. In Singapore, the preferred mode was questioning and discussion, followed by activities and thirdly, teacher talk. All the teachers who made use of teacher talk agreed that it was important to raise students' awareness of values issues and that there is the need to *tell* the students directly about these.

Singapore Iterations (20.00%) indicated that teachers tell students about values (see Fig. 4). Most of the time, it was to raise students' awareness and from that awareness to inculcate values. For instance, teachers tended to tell or "reinforce to them that they should take care of the surroundings that they are blessed with."

New Delhi Iterations (35.71%) indicated that teachers told the students about values issues in order to bring about an awareness of the latter, which according to the teachers would lead to a demonstration of responsible behaviour, such as care (see Fig. 4). In another instance, it was for the purpose of getting a particular message across to students, for example, telling them about hygienic practises. "Yes, we can give the message of cleanliness and hygiene. We should not spread dirt or we should not be unhygienic. We should cover our face while sneezing, while coughing; we should wash our hands before eating."

Other Strategies There were a small number of teachers in Singapore and New Delhi who mentioned the use of multimedia such as videos or movie clips and PowerPoint presentations as strategies for addressing values in science.

Two Singapore teachers indicated the use of video/movie clips in a lesson on teenage pregnancy, mainly to bring home the point about responsibilities involved in taking care of a baby and "issues that they will face when they have a child..." Another teacher used PowerPoint slides to address safety issues in the laboratory prior to a practical session in the laboratory.

In New Delhi, the Internet was recognized for the amount of information it provided, "So many things from internet…a lot of information. I sometimes make my PowerPoint and show them. So many things are not in the book." Teachers also pointed to the use of PowerPoint presentations to address values issues. One teacher prepared PowerPoint slides on atoms and shared them with fellow Grade 8 teachers before their lesson on the Fukushima disaster. This was to enable teachers who were not trained in Physics to teach students the basics about atoms before the discussion on the disaster of the nuclear-melt down and the pros and cons of nuclear reactors.

Teachers' Perception of Challenges they Faced in Infusing Values in Science Lessons The responses from the nine teachers from Singapore and the ten teachers from New Delhi to the question, '*What were the challenges (in infusing values in science lessons)?*' showed three common challenges. These were time and syllabus constraints, teacher competency and student receptivity. Teachers from Singapore and New Delhi showed similar trends in the type and number of responses they made for each challenge (see Fig. 5).

Time and Syllabus Constraint Teachers interviewed in both cities were consistent in referring to the completion of syllabus as a prime focus during lesson time. This resulted in little time for values infusion in science lessons. Teachers in Singapore differentiated values from taught content and felt that content reduction is required to carve out time to address values in science. Examinations and tests were explicitly cited in New Delhi as the reason for shortage of time to conduct values infusion.

Singapore Responses (53.85%) were on time and syllabus constraint (see Fig. 5). There was reference to the need to complete or *cover* the syllabus, which is perceived as content-focused rather than values-focused. One teacher inferred that, "if you want to have more values in the syllabus…some of the syllabus need (s) to be trimmed off." The teachers perceived that there was little integration of values within the syllabus content, and that instead, values were regarded as independent and separate from content. The need to cover the syllabus tended to be associated with the time factor. Time was needed for syllabus coverage, and hence not available for addressing values in science lessons. The implementation of values lessons was

viewed as more time-consuming because, "…if you want a lot of values based lessons…that means you have to have a lot of time for interaction." The time constraint limited the development and implementation of good values-infused lessons. Time constraint also limited the use of meaningful strategies, as one teacher remarked, "... I am only doing ... more of a verbal discussion."

New Delhi Iterations (50.00%) referred to time and syllabus constraint as a major challenge for the infusion of values in science lessons by the teachers (see Fig. 5). There was pressure to complete the syllabus "within a time-frame." Teachers raced through the content to complete the syllabus on time for the examinations, and as one teacher puts it: "so many times we just give them the facts and go ahead." Another teacher's lament was, "having tests again and again and again…" and therefore a need to have the content covered in preparation for the frequent tests. It appeared that teachers did not have the time to carry out their lesson plans due to work overload. There was "pressure to complete the syllabus…and prepare for the examination," one teacher said. This being the case, there was not much time spent on planning for values infused lessons.

Student Readiness Teachers from the Singapore schools thought that students' age placed a limitation on their readiness for values issues while teachers from the New Delhi attributed students' lack of interest and tendency to be distracted as the main factors affecting their readiness for values discussion in science.

Singapore Responses (30.77%) indicated the lack of students' readiness as a limitation to values infusion (see Fig. 5). For instance, teachers perceived that students were unable to *examine* values issues due to their young age (at Grade 8) and that these students would be more able to *articulate* their thoughts and *examine*' issues when they went "to JC[1] or even … upper secondary[2]." There were concerns over discussing values with students, and as one teacher explains, "...the students think that we are swaying (straying) away from science lesson to VE[3] lesson."

New Delhi Responses (31.25%) referred to student readiness as challenges (see Fig. 5). There were some students whose interest needed to be sustained, who, as one teacher felt, "...use their time in other activities like games, in entertainment. They don't want to use their time in such things (values in science lessons); they (think) that these are just wastage of time." This teacher also lamented that students were distracted by Internet chatting, that, "they don't want to study at all." Another teacher commented on students' level of understanding, "Suppose I am taking two sections (classes), sometimes something goes well in one section (class) and may not go well in another section. It depends on the thinking of the students and how much they know about their previous basics."

Teacher Competency Singapore teachers raised concerns with regard to teacher competency in potential content domains for values discussions, while teachers from New Delhi schools

[1] Junior College, grades 11 and 12.
[2] High School, grades seven to ten.
[3] Values Education, a dedicated period teaching values across grades 7 to 10.

pointed to their skills in classroom management as a stumbling block in carrying out values-infused science lessons.

Singapore Another challenge voiced by two teachers was their limited competency in the domain of the life sciences. This constrained their approach towards infusing values in science education. One teacher summed up the challenges faced in infusing values in science lessons as "I think the challenge is not whether is there a place for it but rather how to do it."

New Delhi Teachers' concerns centred on classroom management, where teachers expressed frustration over the students' behaviour in class before the lesson started. Igniting and sustaining students' interest and involvement proved to be challenging. There was consensus amongst three of the teachers that what they perceived initially as challenges was resolved as they gained experience in teaching. As one of them explained, "Initially there were challenges, now... I am experienced and have been teaching for so many years."

Research Question 2

1. *How do values-infused science lessons influence students' disposition and action in selected schools in Singapore and New Delhi?*

Teachers perceived that values lessons in science influenced their students in three ways, namely, (1) changes in attributes (steadfastness, perseverance, confidence), (2) changes in affect (interest, amazement, restlessness and agitation) and (3) changes in action (behaviour). Singapore teachers spoke about changes in attributes and changes in affect as indications of influence of values infused lessons on students, while New Delhi teachers made references to changes in affect and changes in action. For the purpose of this study, *influence* is considered as changes in attributes, affect and action, as articulated by the teachers.

Singapore One teacher was convinced that science had an influence on students' attributes and taught them to be perseverant and steadfast workers, leading to success and confidence building. She explained, "…to me this is important, because from 'don't know to know', I find that along the way they have a lot to learn and then along …time, along the journey, they build their confidence … so the next time they encounter some problem that they face …they can apply the same attitude."

Another teacher recounted how students showed a change in affect, being "restless" and "agitated" when a newspaper clipping on teenage pregnancy was shown on the screen before them, as a part of a lesson that discussed the controversial issue and its consequences. One teacher recounted his/her students' amazement when he/she performed a laboratory experiment to demonstrate how sexually transmitted diseases are propagated.

New Delhi In New Delhi, according to four teachers, students generally showed interest (change in affect) in values-infused science lessons. Teachers were able to gauge students' interest by their level of participation in discussions, and by their attentiveness in class. One teacher mentioned that the topic on Reproduction and Adolescence had a strong influence on her students and ignited their interest and curiosity. She said, "I directly see their expression changing...and with diseases like AIDs, they really want to know how it spreads…[they want]

awareness. In case diseases are hereditary, then I have to explain it. They ask, 'Ma'am, so I will also get it?' … I say, it also depends on your lifestyle." One teacher mentioned, "I give so many examples which raise their curiosity and which make them get interested in science, which make them interested in [the] chapter itself, so that they can be [a] wake ... in the class, they will not sleep in the class..." Another gauged the engagement of students through their responses when asked how they could help disaster victims. She recounted, "they come out with so many answers…so when you collectively list down on the board there will be so many solutions…how can they help the people and all."

Three teachers reported students' reacting to values-infused lessons, one of which was a demonstration of life-skills on how to care for oneself and others during and in the aftermath of natural disasters. Co-incidentally, 2 days after a particular lesson, New Delhi experienced tremors as a result of an earthquake further north of the country. Students put their learning into practice and told one of the teachers "we did whatever was taught to us." The teacher also recounted how a tree planting session she had with her class during a lesson on conservation led to a student-initiated tree planting movement within their own communities, "…They are involving their grandparents also. They are talking to other neighbours also and to those who are not that educated, telling them the importance of plants, how the environment can be…" Another teacher recounted how, after the lesson on food and crop management, students developed the habit of not wasting food as a result of their heightened awareness of the effort involved in the production and preparation of the food they ate. She shared, "children are taking interest and they are talking to their parents about it, they are talking about values of food and not wasting it."

Discussion

Teachers' Perceptions of How Values Are Infused or Addressed in the Teaching of Lower Secondary Science

Teachers' Understanding of 'Values in Science' In this study, most teachers cited category A values (epistemic values inherent in the discipline of science, such as validity, fairness, honesty, rigour) as those that they attempted to infuse in their lessons. In Singapore, for instance, close to 75% of the teachers claimed to have engaged their students with category A values, adopting, in terms of socio-cognitive theory, the direct personal agency approach to convey the values to students. Another 12.5% of teachers made references to category B values, and the same percentage of teachers mentioned C values. This contrasted with the responses of the New Delhi teachers, of whom 50% focused on category A, 10% on category B (values imported into science by practitioners of science and values upheld and practised by scientists) and 40% on category C (values arising from the interaction between scientific processes and products and the world at large). The fact that category B values were rarely mentioned by teachers suggests that the latter seldom made use of the proxy agency approach (the influence of the scientists and the values they champion) in their presentation of values to students. On the other hand, the relatively high representation of category C values suggests that a sizeable number of teachers favoured the use of the collective agency approach in their attempt at values infusion in class.

One of the reasons for these differences might be the relatively heavier emphasis in the Singapore science syllabus on practical skills, with implications that values inherent in science, such as precision, accuracy, validity, honesty and fairness, were highlighted to the students during science practical sessions. On the other hand, in New Delhi, the science syllabus gave greater emphasis to the social impact of science (category C). Unlike the situation in Singapore, the New Delhi teachers hardly mentioned laboratory tasks as part of activities conducted in the classrooms. Furthermore, social issues, such as public outrage over the destruction of forests, the diverting of rivers for dam construction and desalination programmes and the quality of genetically modified food, tend to be widely covered in the Indian media (Aikenhead 2007; Allchin 1999; Corrigan et al. 2007; Hildebrand 2007; Hodson 2003; Jarman and McLune 2007; Rennie 2007) and hence could be areas of focus in the New Delhi classrooms.

It is not surprising that epistemic values should arise in any encounter with science. However, an emphasis on category A values alone tend to characterize formal science, "a conventional, non-controversial, established and reliable science...," as may be the case with the way Singapore teachers portray school science. Category C values characterize science as it features in the real world, reaching students through the mass media. It is a science that is, "controversial, preliminary and under debate" (Hindustan Times 2013; India Blooms 2013a, 2013b; Ling et al. 2009; Rama 2013). In the case of New Delhi, the teachers referred to category A and C values more evenly than in the case of the Singapore schools. However, the scant mention of category B values also indicates that values in science may not have been presented to students in their different dimensions. The presentation of school science to students, with equal emphasis on all three ways in which values intersect with science, will offer students a more realistic image of science, exposing its true nature. In this way, students are given an opportunity to learn about the true nature of science and how every player in a scientific endeavour negotiates values issues. When students are presented with a lopsided view of how values intersect with science, by either not adequately showcasing how practitioners of science bring their values into science or how the processes and products of science interact with society at large, they are given little opportunity to experience the way science interacts in the real world. This would influence the future decisions that they, as informed citizens, make about science. Educating students for responsible citizenship has been identified as an important role of school science (Reis and Galvao 2009).

Allchin wrote, "Ideally, teachers will expose students to the various ways that values apply to science and help them develop skills in distinguishing their differences and in analysing the role of values in producing particular facts." (Berkowitz and Simmons 2003). The findings in this study raise the question of how familiar teachers are with the concept of values in science. It may be that there are limitations in teachers' understanding of the ways values intersect with science and how these values are applicable in science. Teachers' incomplete understanding and appreciation of the application of values in science would undermine the benefits that students may derive from science education (Reis and Galvao 2009; Sadler and Zeidler 2009).

None of the teachers interviewed in Singapore or New Delhi denied the need for values in science. This is in contrast to reports in the literature that indicate that there was a proportion of science teachers who perceived science as value-free (Grace 2006; Reis and Galvao 2009) and that their duty was to just to present scientific facts, according to Merton (as cited in Allchin 1999, p. 2). In the context of Singapore and New Delhi, teachers were able to identify values issues in the specific science topics that they taught and they were not opposed to the infusion of values in science lessons. This is also in line with studies conducted in Singapore and in Tamil Nadu, India, where a large proportion of science teachers indicated the need to address bioethics in science lessons (McKim 2010).

Planning for Values-Related Science Lessons All the teachers interviewed (78.95%), except one from Singapore and three from New Delhi, indicated that they did not plan for values infusion in science lessons. Any mention of values during the lessons was done so spontaneously as values issues arise. The fact that planning is not carried out by most of the teachers raises questions as to whether values were indeed infused in science lessons, as the study assumes. In this study, infusion is defined as a natural, conscious and consistent inclusion or incorporation of instructional strategies, values, attitudes and methods (Macer and Ong 1999; Pandian and Macer 1997) in the subject or lesson. Collective literature on infusion studies show several steps taken in infusion, with one important feature being conscious and purposeful planning of lessons. Planning refers to "decisions that are made about organizing, implementing and evaluating instruction" and incorporates consideration of content of instruction, materials, instructional strategies, teacher behaviour, structure of lesson, learning environment, students, duration of lesson and location of lesson (Robertta 1993). An effective values-infused science lesson would entail both planning and implementation of "appropriate authentic classroom experiences" (Jones et al. 2010, p. 129).

Although teachers claimed to have carried out values lessons in the classroom, the lack of planning by the majority of the teachers suggests an important issue about priority. Were values in science given importance in the science curriulum as indicated in syllabus documents? Values issues may have been sidelined as teachers spent more of their time planning for other student outcomes in science education than dealing with values issues encountered in science. Another possibility is that teachers might have been of the mindset that addressing values in science did not need planning, since they were confident of being able to deal with the issues when they arose. The teachers might not be aware of the depth and breath of the values issues and the need for planning in order to meet desirable outcomes in the students. The earlier findings that the teachers were focussed on either one or two of the three categories provides ground to believe that the teachers might not as yet appreciate what infusion of values in science entails and the importance of engaging students in the process of addressing these values issues.

An absence of planning indicates that teachers did not conceptualize values infusion in their science lessons. One reason for this could be that other demands of the curriculum often left them with insufficient time to address values issues during science lessons. Alternatively, teachers might have been unclear about the discourse on values and its importance in science education. Teachers could also have perceived that incidentally addressing values in the lessons may suffice, and they were not primarily concerned with the outcomes on the students.

Only four out of the 19 teachers interviewed indicated that they planned for values-infusion in their science lessons. One school in New Delhi carried out the most comprehensive values infusion in science lessons. The Fukushima nuclear disaster was the focus of a lesson on atoms. This included the discussion of the pros and cons of installing nuclear reactors. The entire eighth grade and their science teachers were involved in this project. In this school at least, there was an attempt at adopting a socio-cultural, collective agency approach to values infusion, whereby the exposure to values takes the form of a whole-class endeavour involving the combined effort of all the students. There are several reasons for values infusion to be practised in this particular school. Firstly, an issue of interest to the students and the world at large was deliberately chosen. Secondly, the discussion on values was deliberately infused into the lessons in stages. All the teachers in the cohort were involved, indicating the importance the school placed on the initiative. Thirdly, there was recognition of the fact that the teachers needed to have a good grounding in the scientific concepts that would enable a deeper

understanding of the nuclear disaster. Peer teaching was encouraged amongst the teachers. Physics teachers shared knowledge on the relevant subject content with their colleagues. All the above steps were carried out before the teachers finally moved into the classroom and eventually discussed the pros and cons of the issue with their students. For the latter, it appears that a fair ground was established to encourage discussion amongst students and elicit their thoughts on the values issues involved, the parts played by different stakeholders in the entire incident, the interplay between the values of different stakeholders on the issues that arose, and the role of the citizen in all this. However, there is scope for further research on whether the initiative was actually carried out and the extent of its effectiveness.

Strategies Teachers Used for Values-Related Lessons All the teachers interviewed were able to indicate strategies they used to address values in science lessons. The predominant strategies used in both the cities were (1) questions and discussion, (2) activities and (3) teacher talk. In Singapore, activities and questions and discussions were mostly used. In the case of New Delhi, questions and discussions were predominant strategies employed, followed by teacher talk and lastly, activities. In the case of Singapore, activities featured mostly in the classroom setting, while in New Delhi, activities were conducted outdoors.

Questions were used to initiate discussions on issues in a few classrooms in Singapore and New Delhi. The questions were open-ended and elicited divergent viewpoints from the students. However, these were teachers' views. The teachers were aware of the power of questioning techniques to elicit student participation. Though it was evident that there may have been many instances of questions posed to students in the classrooms, the quality of these questions is not indicated, neither was this inquiry within the scope of this research. However, inferences can be drawn from teachers' responses to the interview questions as a whole.

While teachers in both cities indicated questions and discussions as the main strategies, there is evidence that suggests that these were mainly teacher-led discussions through questions posed to students. This method of questioning is opposed to student-centred group or class discussions. Though the use of questioning technique as a strategy to infuse values in science was prevalent, the quality of questions asked was not clear. Evidence from the interview suggests that almost 50% of the teachers interviewed (four out of nine in Singapore and five out of ten in New Delhi) tended to tell students about values. Teacher-led dialogue with students seemed to be a major feature of classroom discourse on values-related lessons in science in the schools from both the cities, suggesting once again a preference for the use of direct personal agency for creating awareness on values.

Recent literature in this area (Boyd 2012) suggests that teachers use questioning as a dominant instructional tool to build upon a lesson according to teachers' pre-set goals, thereby either ignoring or building upon student utterances according to the teacher's intention. According to Boyd, teacher talk can be an effective instructional tool only when teachers are receptive to *student cues*' and are able to negotiate learning by affording the students opportunities to *shape the scope of the discourse*. This is opposed to a common classroom practice where the teacher scaffolds the lesson according to pre-set teacher goals (Burden and Byrd 2007). Usually, according to the literature, "teachers deftly ignore, squelch, evaluate, or build upon student utterances according to teacher intentions, which are captured within the lesson plan and implemented through the dominant instructional tool of questioning…" (Boyd 2012, p. 26). Further studies on the questioning technique used by teachers to infuse values in science teaching will throw some light on the quality of questions teachers pose students in the science classrooms, contributing to effective values-infused science lessons.

Macbeth (2003) pointed out that whole-classroom discussions were mostly led by teachers in the teacher Initiation, pupil Response and teacher Evaluation (I-R-E) fashion. This does not serve to actively promote reasoning skills. In another report on lessons in the UK, Driver et al. (2000) and Office of Standards in Education (2000) reported that the teacher-initiated discourses in science classroom discussions were not a common feature (Grace 2006). This supports Newton's (Newton et al. 1999) report that found little evidence of discussions in science lessons in grades 7 to 11 classes studied. The students' and teachers' responses in this study are reminiscent of this.

In this study, evidence suggests that the Singapore schools appeared to use more student-centred strategies than the New Delhi schools. Singapore schools predominantly used questioning and discussions and activities to conduct values-infused science lessons, while New Delhi teachers resorted primarily to questions and discussions followed closely by teacher talk. The prevalence of teacher talk in New Delhi classrooms implied that student-centred activities might be downplayed. In the case of both cities, teachers indicated that they pose questions to their students and engage in discussions. However, it is not clear how these student-centred approaches were considering the fact that about 50% of teachers from both cities tend to tell their students about values. The varied classroom and laboratory activities conducted in Singapore classrooms indicate that Singapore teachers may be using more student-centred strategies compared with their New Delhi counterparts, in the overall analysis.

Furthermore, with regard to New Delhi, Koul and Fisher (2002) reported that students in India play a passive-receptive role. This was attributed to a transmissive pedagogy and overloaded curriculum which was directly linked to the high-stake examination-oriented system, thereby restricting the range of pedagogic approaches (Boyd 2012). This point is supported in the next section on challenges that teachers face.

Extant literature on values in science suggests that students benefit from student-centred approaches to the discourse on values in science education (Lyons 2006). Generating ethical thinking or thoughts on values in science in the classrooms demand more than "an intuitive response to questions, issues and problems that have a moral overlay" (McKim 2010, p. 26). Studies in Bioethics, Socio-Scientific Issues (SSI), Science, Technology, Society and Environment (STSE) and Science Technology and Society (STS) point to the teachers' knowledge as central to the students' authentic classroom experiences (De Luca 2010, p. 87). Besides, Reis and Galvao (2009) showed through a case study that "the implementation of discussion activities about controversial socio-scientific issues depends decisively on the teacher's convictions about the educational relevance of these activities and the knowledge needed for their design, management and assessment." They concluded that teacher competencies in this area can be "triggered by professional development opportunities in which the teacher experiences new approaches under expert supervision." (Reis and Galvao 2009, p 16). In a student-centred approach to values in science, the teacher's role is facilitative. This includes "assisting students to examine and evaluate controversial issues critically, from multiple perspectives, using a good decision making model" (Buntting and Ryan 2010, p. 52; Conner 2010, p. 65; Sadler et al. 2006, p. 357). It requires focused planning and student-centred approaches for effective grounding in the values issues interwoven in the process and products of science. There is also a need for students to appreciate the interplay of various forces in the practice of science with the aim of developing students into sound decision makers in their daily dealings with the processes and products of science.

Challenges Faced by Teachers in Infusing Values in Science Lessons Teachers from both Singapore and New Delhi identified similar challenges to infusing values in science lessons. These were (1) time and syllabus constraints, (2) lack of student readiness and (3) lack of teacher competency. A review of the literature on this subject identified similar challenges (McKim 2010, p. 26).

The predominant challenges were time and syllabus constraints. It was the prime responsibility of teachers to complete the syllabus and prepare the students for examinations. The teachers' responses confirmed that although syllabus documents prepared in New Delhi and Singapore made references to the importance of making science relevant to the lives of students and of appreciating the interaction of science with the society and environment (McKim 2010; Sadler et al. 2006), actualizing these aims were very much left to the teachers' initiative and imagination. In an exam-oriented system, non-examinable student outcomes were generally side lined against the more pressing needs of meeting examination requirements of subject mastery and process skills. As a result of this, teachers might have been left with little time to plan, prepare and execute values lesson, as echoed in the literature (CPDD 2008; NCERT 2007).

The second constraint was student readiness, in terms of cognitive ability or maturity to examine values issues and in terms of student expectation of what teachers ought to teach. This perception of student level of maturity as a concern, though only voiced by two teachers, contrasted with a study carried out with Korean children aged between 11 and 12, who were able to express value-laden emotions in their narratives about environmental problems (Grace 2006; McKim 2010). Another study conducted in New Zealand schools with four groups of children between the age range of 5 and 12 to examine ethics teaching and learning in biology-related context showed that the students had the potential to understand ethical ideas. Significantly, the teachers were impressed that the students were able to engage with the particular issues presented to them, developing responses that they articulated and justified (Kim and Roth 2008). Furthermore, researchers like Piaget and Kohlberg have shown the moral development of children in stages. The stages are not necessarily age specific. A 14-year-old children could be anywhere between stages two and four. In another study, Jones et al. (2007 in Reiss 2010) developed a range of indicators of progression in ethical reasoning in science. The researchers were convinced that every student was able to consider right and wrong starting from a personal perspective (egocentric) and progressing to peers, to national and to the global. Furthermore, progression along the spectrum depends on "individuals around them, the particular scientific or technological issues being considered, their motivation and a range of other factors" (Buntting and Ryan 2010, p. 50). In terms of socio-cognitive theory, the implication is that all three modes of agency (personal, proxy and collective) could and should be involved in the process of values infusion.

Another aspect about student readiness reported by teachers was when students raised objections when they ventured into values discussions in their usual science lessons. One Singapore teacher expressed weariness in discussing values in science because of such reactions from their students. This shows that students might have fixed expectations from their teachers as to how science has to be taught. Such views suggest that students perceived the nature of science as being value-free. An area for further research could be on how students perceive the nature of science and what the determining factors are. Further studies could centre on classroom dynamics that contribute to the way students perceive the nature of science. Teachers' weariness in infusing values in science lessons also points to teachers' lack of confidence in addressing values in science or a weak

conviction in the worth of infusing values in science. Such a notion has been documented in the literature, such as, "…SSI (Socio-Scientific Issues) are usually value laden and, the juxtaposition of science and ethics can be uncomfortable for scientists, teachers and students who define science in terms of objectivity" (Reiss 2010, pp. 14–15).

In New Delhi, teachers perceived student readiness or the lack of it by whether students were attentive during lessons or not. In a few of the schools, teachers reported that some of the students were inattentive during the lesson. This could arise from teachers' inability to reach out to students through relevant and meaningful activities in order to engage them. These concerns have also been documented in the literature (Sadler et al. 2006).

The last constraint identified was teacher competency. Two teachers from the same school in Singapore lamented over their lack of confidence in Biology as a barrier in infusing values in their science teaching, since they felt a need to know the details of values-issues discussed. In New Delhi, the concern over teacher competency revolved around classroom management. Disinterested students who needed disciplining took the time away from meaningful teaching. In both contexts, the teachers lacked confidence as they perceived that there were gaps in their subject and pedagogical content knowledge, and these limitations hindered their ability to conduct values-infused science lessons. They felt that they were not able to engage their students effectively, either because they did not have the content knowledge to do so (in the case of some of the Singapore teachers) or because they did not adopt the appropriate pedagogies to sustain students' interest and involvement. However, it was a belief amongst some teachers that these concerns would dissipate as they gather more experience in teaching, probably due to acquisition and adoption of the suitable approaches over time.

The concerns identified suggest two possible areas of intervention, in infusing values in science lessons. Firstly, adjustments could be made in the curriculum, giving importance to examining values issues in science. In addition, space and time could be given to teachers in the science curriculum to carry out comprehensive student-centred discourse in values during science lessons at least once a term (i.e. once in ten weeks), complete with activities, assignments and evaluations of pupil outcome. Secondly, professional training for teachers would serve to improve facilitation skills for the purpose of carrying out effective student-centred discussions in class. Professional help could also be offered to teachers to enable them to gain exposure to debates on the nature of science and to help bring about an awareness of science as it is practised and presented in society.

There also needs to be a different approach to preparing science teachers in pre-service courses. Currently, schoolteachers are put on a specialization track where they specialize either in Chemistry, Physics or Biology or any two of these or one of these science subjects and one other subject. There is a need for science teachers to appreciate science as a discipline without demarcations while they specialize in one or two of these science subjects. This will enable them to also appreciate values issues in not only a selected topic, such as Biology, but also across science, in areas of Physics and Chemistry. They will thus be better able to approach values in science with confidence in the science classroom. Teachers also need exposure to the history, sociology and history of science in order to appreciate the role of values in science.

Teachers' Perceptions of the Influence of Values-Infused Science Lessons on Students

Impact on Students The teachers perceived students to be influenced by values in science lessons in three ways, namely (1) changes in personal attributes (perseverance, steadfastness, confidence), (2) changes in affect or emotions (interest, curiosity, restlessness, agitation,

amazement) and (3) changes in action (carrying out an action as a result of values lessons—e.g. tree planting).

Teachers in both Singapore and New Delhi mentioned changes in affect. In addition, Singapore teachers mentioned changes in attributes while New Delhi teachers mentioned changes in action. During some science lessons when values were discussed, teachers reported changes in affect, whereby students were "restless," "agitated" or were filled with "amazement." Teachers in New Delhi perceived their students' "interest" and "curiosity". These observations suggest that students' positive response to values infusion in science, as was observed in a study on the outcomes of bioethics on students (Grace 2006). However, students' engagement in the lesson may also be a direct outcome of teachers' own enthusiasm for the topic (Dawson 2010). Teachers' mentions of changes in students' attributes and in behaviour, following values-infused science lessons suggest a possibility that values-infused lessons could have instilled some motivation on the students' part to change their attitudes or to take action in response to what was discussed in the classroom.

Limitations The teachers' claims implied possible psychological changes and further studies need to be conducted to ascertain and measure these changes and to identify the underlying motivating factors. The interviews used in this research sought merely to gauge teachers' perception of how values lessons influenced their students. The findings did not account for what teachers understood by the terms *influence*' or *impact*, neither did it seek to measure qualitatively or quantitatively the actual influence of values infused lessons on students as evidenced in changes in their behaviour. Furthermore, these interviews sought teachers' opinions directly, irrespective of any bias, and as such, may not reflect reality. More reliable data could be obtained from a focused study based on field observations conducted through a series of values infused science lessons, followed up by a qualitative study of the effect of these lessons on the students. The data could be used to inform choices to be made for lesson preparations, as well as the methods and strategies to be used to deliver values-infused lessons. Information on the extent to which students are influenced by values-infused science lessons can also be used in the qualitative evaluation of the effectiveness of the teaching programme.

Best Practices

Singapore teachers used diverse teaching strategies while infusing values in science lessons, thus engaging students better and creating interest in their students to a larger extent. These ranged from question-and-answer techniques, hands-on activities in the classroom on group tasks and in the laboratory through science practical sessions, and engagement of students in the lesson through print resources such as newspaper clippings on relevant and current issues in science that served to raise interest as well as awareness, and non-print resources such as video clips on controversial issues such as pre-marital sex and family planning. The media, if channelled appropriately, could serve as an effective proxy agent for creating awareness on values issues.

Amongst all the cases of infusion of values in science revealed in the course of the interviews with teachers, one school in New Delhi offered a more comprehensive case of values infusion, showing the involvement of personal, proxy and collective agencies in accordance to socio-cognitive theory. A lesson on atoms and the controversial issues surrounding nuclear power is presented here, as a showcase of good practises since it included a comprehensively planned infusion activity involving the entire cohort of Grade 8 students and their science teachers. The

topic included the discussion of the pros and cons for the installation of nuclear reactors on land. There are aspects of this infusion process that set it apart from other examples that arose from other schools. In the first instance, an issue of interest to the students and the world at large was deliberately chosen. It was a then current topic, with public media constantly airing information about the disaster. Next, the discussion on values was consciously infused into the lessons in stages with the involvement of all the teachers in the cohort, indicating the importance the school placed on the initiative. Lastly, there was recognition of the fact that the teachers needed to have a good grounding in the scientific concepts that would enable a deeper understanding of the disaster and therefore the values issues inherent. Peer teaching was encouraged amongst the teachers. Physics teachers shared knowledge on the relevant subject content with their colleagues. All the above steps were carried out before the teachers went into the classroom and eventually discussed the pros and cons of the issue with the students. It appears that a fair ground was established to encourage discussion amongst students and to elicit their thoughts on the values issues involved, the parts played by different stakeholders in the entire incident, the interplay between the values of different stakeholders on the issues that arose and the role of the citizen in the disaster.

Conclusion

At the start of this article, we established the need for values education to be included in school curricula. We queried about teachers' views on the infusion of values in science teaching and its influence on students' attitude and behaviour. In summary, the study showed that teachers in both Singapore and New Delhi claimed to have infused values in their science lessons to some extent, embracing a humanistic approach to science teaching. Likewise, teachers participating in the study believed in the infusion of values in science, showing their understanding of the nature of science. The study revealed the need for more support to be given to teachers in terms of availability of print resources and exposure to discourse on values in science. This includes exposure to the content knowledge of values in science and the skills needed for effective facilitation of values-infused science lessons in class. In both contexts, teachers involved in the study faced the problem of values infusion being side-lined inadvertently as they tried to fulfil expectations with regard to examination outcomes.

Nevertheless, teachers in both Singapore and New Delhi observed that the values-infused science lessons had a generally positive influence on their students and brought about changes in the latter's attributes, affect and behaviour. Teachers felt rewarded for their efforts when their students showed increased interest and curiosity in tandem with greater awareness of social and ethical issues. In some instances at least, teachers claimed that there was translation of knowledge into action as students put into practice the values learned in class.

Compliance with Ethical Standards

Declarations This manuscript has not been published elsewhere and has not been submitted simultaneously for publication elsewhere.

Ethics statement This study was conducted in compliance with appropriate ethical standards in the treatment of the participants.

Conflict of Interest The authors declare that they have no conflicts of interest.

References

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research in science education* (pp. 881–910). New Jersey: Lawrence Erlbaum Associates, Inc..

Allchin, D. (1998). Values in science: an introduction. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 1083–1092): Kluwer Academic Publishers.

Allchin, D. (1999). Values in science: an educational perspective. *Science and Education, 8*, 1–12.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44*(9), 1175.

Bandura, A. (2002). Social cognitive theory in cultural context. *Applied Psychology, 51*, 269–290. doi:10.1111/1464-0597.00092.

Beachum, F. D., McCray, C. R., Yawn, C. D., & Obiakor, F. E. (2013). Support and importance of character education: pre-service teacher perceptions. *Education, 133*(4), 470–480.

Berkowitz, M.W., & Simmons, P. (2003). Integrating science education and characater education. In D. Zeidler, L (Ed.), The role of moral reasoning on socioscientific issues and discourse in science education (pp. 81–94). Singapore: Kluwer Academic Publishers.

Boyd, M. P. (2012). Planning and realigning a lesson in response to student contributions. *Elementary School Journal, 113*(1), 25–51.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*, 77–101.

Bryan, L. A., & Atwater, M. M. (2002). Teacher beliefs and cultural models: a challenge for science teacher preparation programs. *Science Education, 86*(6), 821–839.

Buntting, C., & Ryan, B. (2010). In the classroom: exploring ethical issues with young pupils. In A. Jones, A. McKim & M. Reiss (Eds.), Ethics in the science and techology classroom: a new approach to teaching and learning (pp. 37 to 53). Rotterdam: Sense Publishers

Burden, P. R., & Byrd, D. M. (2007). *Methods for effective teaching*. USA: Pearson Education, Inc..

Campbell, T. (1996). Technology, multimedia, and qualitative research in education. *Journal of Research on Computing in Education, 30*(9), 122–133.

Cauquelin, J., Lim, P., & Mayer-Konig, B. (2000). *Asian values—encounter with diversity*. Surrey: Curzon Press.

Conner, L. (2010). In the classroom: approaches to bioethics for senior students. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom: a new approach to teaching and learning* (pp. 55–67). Rotterdam: Sense Publishers.

Corrigan, D., Dillon, J., & Gunstone, R. (Eds.). (2007). *Re-emergence of values in science education*. The Netherlands: Sense Publishers.

Crabtree, B. F., & Miller, W. L. (1999). Using codes and manuals—a template organising style of interpretation. In B. F. Crabtree & W. L. Miller (Eds.), *Doing qualitative research* (2nd ed., p. 406). California: Sage Publications.

Creswell, J. W. (2012). *Qualitative inquiry and research design: choosing among five approaches*. Thousand Oaks, CA: Sage.

Creswell, J. W. (2014). *Educational research: planning, conducting and evaluating quantitative and qualitative research* (4th ed.). Harlow, England: Pearson Education.

Curriculum Planning and Development Division (CPDD). (2008). *Science syllabus, Lower Secondary, Express/Normal (Academic)*. Retrieved from http://www.moe.gov.sg/education/syllabuses/sciences/

Dawson, V. (2010). Outcomes of bioethics education in secondary school science : two Australian case studies. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom, a new approach to teaching and learning* (pp. 69–86). Rotterdam: Sense Publishers.

De Luca, R. (2010). Using narrative for ethical thinking. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom: a new approach to teaching and learning*. Rotterdam: Sense Publishers.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education., 84*(3), 287–312.

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating rigor using thematic analysis: a hybrid approach of inductive and deductive coding and theme development. *Iternational Journal of Qualitative Methods, 5*(1), 80–92.

Forkner, C. B. (2012). The impact of the enlightenment and colonialism on higher education in India. *Global Education Journal, 2012*(3), 65–71.

Grace, M. (2006). Teaching citizenship through science: socio-scientific issues as an important component of citizenship. *Prospero, 12*(3), 42–53.

Hays, D. G., & Singh, A. A. (2012). *Qualitative inquiry in clinical and educational settings* Available from http://site.ebrary.com/lib/nielib/docDetail.action?docID=10496794

Held, D., & McGrew, A. (2002). *Governing globalisation*. London: Polity.
Hildebrand, G. M. (2007). Diversity, values and the science curriculum. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The re-emergence of values in science education* (1st ed., pp. 45–60). Rotterdam: Sense Publishers.
Hindustan Times. (2013). The PMO is talking the GMO language but people will fight it out. *Hindustan Times*.
Hodson, D. (2003). Time for action: science education for an alternative future. *International Journal of Science Education, 25*(6), 645–670.
India Blooms. (2013a). Citizens protest against GMO's, Mosanto, Brai Bill. *India Blooms*.
India Blooms. (2013b). India's waterman to mobilise masses. *India Blooms.*
Jacobs, G. M., & Reetz, L. J. (1999). Faculty focus on moral and character edueation. *Education, 120*(2), 208–212.
Jarman, R., & McLune, B. (2007). *Developing scientific literacy: using news media in the classroom*. Buckingham: GBR: Open University Press.
Joffee, H. (2012). Thematic analysis. In D. Harper & A. R. Thompson (Eds.), *Qualitative research methods in mental health and psychotherapy- A guide for students and practitioners*: John Wiley and Sons.
Jones, A., McKim, A., & Reiss, M. (2010). The enhancement of ethical thinking. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom*. Rotterdam: Sense Publishers.
Key, J. P. (1997). Module R14: qualitative research. Retrieved 7 September 2014, from James P. Key. Oklahoma State University. Retrieved from, http://okstate.edu/ag/agedcm4h/academic/aged5980a/5980/newpage21.htm
Kim, M., & Roth, W.-M. (2008). Rethinking the ethics of scientific knowledge: a case study of teaching the environment in science classrooms. *Asia Pacific Education Review, 9*(4), 516–528.
Koul, R., & Fisher, D. (2002). Science classroom learning environments in India. Paper presented at the International Educational Research Conference of the Australian Association for Research in Education (AARE). Brisbane, Australia.
Kwong, M. J., & Bartholomew, K. (2011). 'Not just a dog': an attachment perspective on relationships with assistance dogs. *Attachment and Human Development, 13*(5), 421–436.
Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry* (Vol. 75). Sage.
Ling, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., et al. (2009). Preservice teachers' views about nature of scientific knowledge development: an international collaboratve study. *International Journal of Science & Mathematics Education, 7*(5), 987–1012.
Lyons, T. (2006). Different countries, same science classes: Students' experience of school science in their own words. *International Journal of Science Education, 28*(6), 591–613.
Macbeth, D. (2003). Hugh Mehan's learning lessons reconsidered: on the differences between the naturalistic and critical analysis of classroom discourse. *American Educational Research Journal, 40*(1), 239–280.
Macer, D., & Ong, C. C. (1999). Bioethics education among Singapore high school science teachers. *Eubios Journal of Asian and International Bioethics, 9*, 138–145 *9*, 138-144.
McKim, A. (2010). Bioethics education. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom: a new approach to teaching and learning* (pp. 19–36). Rotterdam: Sense Publishers.
Musa, A., & Khawaldah, A. (2007). The degree of teachers' compliance with social values in practicing education. *Um Alqura for Educational Science, 19*(1), 179–222.
National Council of Educational Research and Training (NCERT). (2007). *National Curriculum Framework 2005—syllabus for classes at the elementary level*. New Delhi: National Council of Educational Research and Training.
Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies, 19*(4), 317–328.
Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in pedagogy of school science. *International Journal of Science Education, 21*(5), 553–576.
OFSTED (Office of Standards in Education). (2000). *Progress in key stage 3*. London: OFSTED.
Pajares, M. F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research, 62*(3), 307–332.
Pandian, C., & Macer, D. (1997). *Bioethics in India: Proceedings of the International Bioethics Workshop in Madras*. Paper presented at the Biomanagement of Biogeoresources, Madras.
Paul, P., Roy, A., & Mukhopadhyay, K. (2006). The impact of cultural values on marketing ethical norms: a study in India and the United States. *Journal of International Marketing, 14*(4), 28–56.
Rama, L. (2013). (Spirit of activism in India) Activism (or exile?) on protest street. Washingtonpost.com. Retrieved from http://www.highbeam.com/doc/1P2-34462879.html
Reis, P., & Galvao, C. (2009). Teaching controversial socio-scientific issues in biology and geology classes: a case study. *Electronic Journal of Science Education, 13*(1), 162–185.
Reiss, M. (2010). Ethical thinking. In A. Jones, A. McKim, & M. Reiss (Eds.), *Ethics in the science and technology classroom* (pp. 7–17). Rotterdam: Sense Publishers.
Rennie, L. (2007). Values of science in out-of-school context. In D. Corrigan, J. Dillon, & R. Gunstone (Eds.), *The re-emergence of values in science education*. Rotterdam: Sense Publishers.
Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. *Handbook of research on teacher education, 2*, 102–119.

Robertta, B. H. (1993). *Multicultural infusion: A strategy for science teacher preparation*. Paper presented at the Annual Meeting of the National Association for Research in Science Teaching. Retrieved from http://eric.ed.gov/?id=ED356229

Rondinelli, D. A., & Cheema, S. G. (2003). The competent state: governance and administration in an era of globalization. *Reinventing Government for the Twenty-First Century: State Capacity in a Globalizing Society (Bloomfield CT: Kumarian Press, 1997)*, 243–260.

Ryan, A. (2008). Indigenous knowledge in the science curriculum: avoiding neo-colonialism. *Cultural Studies of Science Education, 3*(3), 663–702.

Sadler, T. D., Amirshokoohi, A., Kazempour, M., & Allspaw, K. M. (2006). Socioscience and ethics in science classrooms: teacher perspectives and strategies. *Journal of Research in Science Teaching, 43*(4), 353–376.

Sadler, T. D., & Zeidler, D. L. (2009). Scientific literacy, PISA, and socioscientific discourse: assessment for progressive aims of science education. *Journal of Research in Science Teaching, 46*(8), 909–921.

Sharma, D., & Mohite, P. (2007). Teachers' perceptions of values education for children. *Critical perspectives on values education in Asia*, 30–49.

Sutrop, M. (2015). Can values be taught? The myth of value-free education. *TRAMES: A Journal Of The Humanities & Social Sciences, 19*(2), 189–202. doi:10.3176/tr.2015.2.06.

Taylor, P. (1990). The influence of teacher beliefs on constructivist teaching practices. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA, USA.

Temlı, Y., Şen, D., & Akar, H. (2011). A study on primary classroom and social studies teachers' perceptions of moral education and their development and learning. *Educational Sciences: Theory & Practice, 11*(4), 2061–2067.

Triandis, H. C., Bontempo, R., Villareal, M. J., Asai, M., & Lucca, N. (1988). Individualism and collectivism: cross-cultural perspectives on self-ingroup relationships. *Journal of Personality and Social Psychology, 54*(2), 323.

Valenzuela, D., & Shrivastava, P. (2008). Interview as a method for qualitative research. *Southern Cross University and the Southern Cross Institute of Action Research.(SCIAR).* Retrieved from, http://www.public.asu.edu/~kroel/www500/Interview Fri.pdf.

Venkateswaran, T. V. (2007). Science and colonialism. *Content and character of natural sciences in the vernacular school education in the madras presidency Science and Education, 16*(1), 87–114.

Wood, R. W. (1999). Administrators' perceptions of character education. *Education, 720*(2), 213–219.