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Values in Science and Science Education

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Moral development theories clearly indicate the importance of focusing on values through education. The assertions made with regard to the nature of science as value-laden makes the case for value focus in science and science education at all levels. However, studies with regard to values in general, value education, values in different subject areas and values in science education are found to be limited. Educational research in values in science and science education has been both relatively recent and scarce. Nevertheless, In order to make a case for the current study and substantiate the relevance of the same, a very systematic analysis of the previous researches conducted becomes necessary. A review of related literature provides a deeper understanding of the nature, scope, and significance of the study. Keeping this in view, the present paper throws light upon the researches conducted in the area of values, value education, values in various subjects, and values in science and science education. The critical examination of the available literature in this area is presented in the form of various sections.

Traditional and New Approaches to the Study of Values

The concept of 'values' in the social sciences is often used rather loosely. It can have different meanings in different disciplines. The RCEP[2] (1998) report titled, 'Setting Environmental Standards' has explored a range of methods for articulating values, including recent approaches to incorporating values into decision-making procedures. The range of terms in use to describe 'values' in a general sense includes opinion, belief, attitude, value and worldview, the first three being biased towards interviewees' knowledge and understanding of '*what is*' and the last two being focused more on the moral and ethical dimension, '*what ought to be*'.

In practice, correlation of values, attitudes or norms with behaviour has generally been found to be rather weak (see for example Rundmo 1998). However, it is common to find strong correlations among related attitude and value concepts. For example, a survey was conducted (Buss & Craik 1983) to assess attitudes to changes in industrial societies (including environmental quality) and to examine implications for risk perception and societal decision-making. Attitudes and beliefs were related in predictable ways to: (i) the perceived risk associated with selected technologies, (ii) preferences for the manner in which societal decisions should be made, and (iii) a coherent set of psychological variables. Research with a focus on values alone is much less common than studies of values in the context of opinions, beliefs, and/or norms. Machamer and Douglas (1998) introduced the concept of values and explored the role they might play in science. The paper discusses the different types of value relevant to science and proposes that we need better ways to express the concept. Dealing effectively with the issue of values, including those relevant to science is seen to demand a multidisciplinary approach along with rigorous training in relevant disciplines.

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The term value is said to be an enduring belief, which guides one's actions, one's attitudes and one's judgments beyond immediate goals to more ultimate goals. According to Devi (2004), a value is said to attain three levels of manifestations. Firstly it manifests as professed value of what we believe in, an operational value of what we practice and a dynamic value of what we learn from our experiences. In the current study the researcher focused only on the first manifestation of value of the teachers and their respective students. Such values, as we have seen in the previous chapter have been defined in various ways by various educationists as well as philosophers. They have also been classified differently using different criteria.

Scholars have tried to make various classifications of values as personal, social and spiritual values, though there is no unanimity with respect to boundaries between each. Personal values consist of the qualities with primary reference to oneself. Social values have a direct bearing on the human unity and togetherness. Spiritual values add a new dimension to the social and personal values. On the other hand, Mascarenhas and Justa (1989) classified values as professed values, operational values and dynamic values. They explained professed values as those, which people publicly uphold. Operational values are defined to include values, which people actually practice. They defined dynamic values as those that people learn from experience in order to adopt and renew. In yet another study Shetty (1997) identified four types of values namely, human, social, cultural and institutional values to be introduced into the educational system. In another study Bansal, (1981) listed some values that can be sought in the curriculum like Instrumental Vs. Consummatory; Immediate Vs. Deferred; Cultural Vs. Vocational; Personal Vs. Social and Child Vs. Adult.

On the basis of the available literature, a number of values can be identified which can be conveyed through the process of education. These values like spiritual, personal, social, ethical, moral, human, cultural, scientific, aesthetic, democratic, secular, political, economic, national etc. are said to have their own specific descriptions manifesting themselves in some form or context in the history of humanity. Government of India in its National Educational Policy (1986) developed a comprehensive classification of values to be conveyed through the curriculum. National Educational Policy (1986) classified all the values into three main categories namely Personal values, Social values and National values, which are mutually exclusive and all-inclusive. National Educational Policy (1986) highlighted these three as the essential and fundamental values for the purpose of education, especially at the school level.

With regard to science, it is found that science does express a wealth of *epistemic values* and inevitably incorporates *cultural values. Epistemic* values include controlled observation, interventive experiments, confirmation of predictions, repeatability and, statistical analysis. While the pursuit of scientific knowledge implies a certain set of characteristically "scientific" values, the relevance of other values in the practice of science are not thereby eclipsed. Moreover, science is not exempt from other social values and ethics. A person's scientific contributions will be shaped by the domain of his or her resources or values. The possibly paradoxical conclusion is that one should not eliminate personal or social values from science.

Research on Value Development

Value development or moral development is a long-term process beginning from childhood and continues through adolescent stage to the adulthood. Main developmental years of children in their moral domain, is of the school years, i.e. during the adolescent stage (Piaget, 1965; Kohlberg, 1964), therefore the schools atmosphere should be conducive to moral development. In addition, the curriculum should cater the needs of the children for their effective moral development. Some studies reveal that the school curricula that are in balance with the various

stages of moral development have positive effects on the effective moral development of the children.

In a study on 'Understanding the Adolescent' by the Mavericks learning center at Memorial Middle School based in the United States of America, researchers observed the physical, social, emotional, moral, and intellectual development of the sixth grade class. Recognizing that there is a wide range of development within a class, the study provided some basic information about adolescent development. They also presented the observations of adolescents at Memorial, and strategies for effectively teaching adolescents. Their observations with regard to moral development reveal that the adolescent goes through numerous changes during these years of transformation. They want to be independent and yet, they still have a need for guidance and a place of nurturing and acceptance. Teacher and other adults need to realize and try to understand the changes that are occurring among children of this age. Young adolescents require freedom; however they need to be assured of a sense of security in their lives. With regard to moral development in particular, this age group is beginning to develop their own views on matters of value and morality. They are slowly developing their own judgments and not relying on those of their parents or other adult figures. It is important that we realize the changes these students are going through.

The research at memorial school posed the question "If you could change anything you want, what would it be?" to some of the students on the team. Almost all of their answers fit somewhere within stage 2 or 3. Although many of the things they'd change would benefit them, there seemed to be some "popular ideas" that would benefit or be liked by other students as well.

The analysis of their study revealed that the Maverick's curriculum balances between the concrete operational stage and the formal operations stage as propounded by Piaget. While math and science tend to weigh heavily on the first stage, language arts, reading, and social studies require abstract reasoning. Aspects of the formal operations stage were evident throughout Memorial. For example, emphasis on serving creates a socio-centrism that helps students mature. Other characteristics, considered more negative, are evident in the students who verbally rebel against authority and those who act "stupid" in order to conform.

The Kohlberg "moral development" theory holds that several levels of moral development exist in mankind in all cultures (Kohlberg, 1973). A student's response to a teacher's questions indicates the student's level of moral development. The teacher then constructs and presents to the student dilemmas that should lead the student to a higher level. This demands a complicated teaching strategy in order to be effective and seems to lend itself to smaller classes with young students, who may be more ready to move from one moral developmental stage to another. Beyer (1976) has provided an enriching description of how to use the Kohlberg hierarchy. Although the experiences relate to the elementary school, the basic approach and the classroom organization seem adaptable to a university classroom. A convincing example of how to use it with and environmental problem was presented by Miles (1976). However, Piburn (1976) suggested that incorporating values education in biology classroom may have major obstacles: only 10% of adults operate at the highest moral level. Piburn's informal studies have shown that science students reason morally at lower levels than students in the humanities. He has also discussed the application of Kohlberg's thinking in developing values education in the classroom adapted from the social sciences, while Lockwood (1978) reviewed the effects of moral development curricula and value clarification on students.

It can be observed that one of the persistent legacies from 1960s is a concern with values and ethics. Though the literature is available on the successes and failures, hopes and dreams of teaching about values and valuing, this concern is manifest in elementary schools, is present to a lesser extent in secondary schools (Collie 1979), and is almost absent in the

universities and colleges. Review reveals similar observations also at the secondary level of school education, both in India and abroad. There is a dire need to address this gap.

Studies on Value Education

The literature on values or value education, in India or elsewhere is very limited. Moreover, literature on value aspect in education is limited to subjects like languages, social sciences etc. However, the importance of values in education and value education has not been undermined anywhere in the world. Many studies have been conducted on different aspects of "values/ value education" in India, since independence. Venkataiah and Sandhya (2002) cited a study by Pandya, who studied the place of philosophical and practical values in education. He suggested for a reorganization of the system of education with certain basic values for restoring harmony and poise into human life and society. Seshadri (1984) concluded, "In its full range of meaning, value education includes developing the appropriate sensibilities like moral, aesthetic, cultural and spiritual. The ability to make proper judgments and choose among the competing values, internalize values and realize them in one's life. It thus spans the entire domain of learning – the cognitive, affective and the psychomotor and includes knowledge, understanding and appreciation of our cultural, moral, aesthetic and spiritual values, education of the emotions and the training of the heart and the development of the character".

Gupta (2000) explains that the value education is wider, practicable and adaptable than religious education or moral education, as no specific faith or religion is reflected through ethical, moral, social, cultural or spiritual values. This would mean that value education is instruction in the entire realm of values – physical, emotional, intellectual, imaginative, aesthetic, and democratic, scientific, social, moral and spiritual for any individual. Bhat (1996) elaborated the concept of value education relevant to elementary, secondary, college and university levels, with an objective of the development of an individual, character-building and upholding the human dignity and self-respect.

In India, few studies were conducted with regard to the various aspects of values of the curriculum and relevant syllabi for schools, colleges and teacher education. Various textbooks have been analysed for the presence or absence of value components. These studies have made suggestions to incorporate more of value components in all school subjects.

Studies on textbook analysis for the presence of value components have been conducted on various subjects like languages and social sciences during the past few decades. Haq (1973), in his analysis of Hindi, History, Civics and English textbooks found neither a systematic pattern nor any consistency in the presentation of values. The mental maturity of the students was not taken into account. He also found that the language textbooks of IX, X and XI classes were written entirely from a literary point of view and value components did not find sufficient place. Chaudhari (1985) and Chaudhari (1986) analysed Hindi textbooks of the primary classes. They found that values like scientific outlook, justice, simple living and duty consciousness were given the least importance in the textbooks upto VII standard. While comparing the NCERT textbooks and the books published by the State Corporation in this area, they found that values like courage and adventure were emphasized in NCERT books. Patriotism was significantly represented in the other textbooks. In another textbook analysis, Rajagopal (1989), studied value awareness and value orientation of XII standard students in Tamil textbooks. He compared the value awareness of government school students with management and missionary school students. He found that the former stood better in value awareness than the latter. He also found that value awareness of the students was greater in poetry than in the prose portion of the textbook. In a similar study on value perceptions of students, Bhargavi (1990) found that IX standard boys

identified more democratic values than girls in English prose. Girls identified more social values than boys. Boys and girls both identified religious, personal and aesthetic values equally well level in English prose.

The review of the studies on textbook analysis in the area of values reveals that insignificant consideration is given to looking at value aspects in science. There are few studies on science textbook analysis in India. Many of these studies have been conducted by NCERT. Studies where students identified relevant values in science or science textbooks are almost absent.

Some studies focused on the orientation of teachers as it has a significant impact on the way they set out to impart value education. In addition, the responsibility to develop right value systems to the students necessitates on the part of the teachers to use various teaching strategies that facilitate the process of value development. As the values of the students are affected deeply through the relationship with the teachers, they should embody the requisite values and serve as models whose qualities inspire emulation to the students. Joshi (1983) points out that the secret of teaching values is to inspire and kindle the quest among the students by means of one's own example of character and mastery of knowledge. It is by embodying the values within ourselves that we can really radiate values to our students. Teachers are continually placed in the position of decision-making, sometimes split-second, sometimes pre-planned- about a particular class. These concern, for example, with the content to be taught, the pedagogical strategies employed, the disciplinary organization of the class, and so on (Bishop, 2000). He contends that more knowledge teachers of science, mathematics or any other subject for that matter have about the values they are teaching, the better informed will be their judgments. Sandhya (1999) conducted an evaluative study on value education provided at the tenth standard level in Mysore district on a sample of 191 teachers teaching tenth standard. The study found that theoretical, social and economic values are predominant among the teachers in that order, followed by political, aesthetic and moral values. The theoretical value occupies the highest place among the values maintained by the teachers. Secondly, comparison between men and women revealed that they did not significantly differ in all the above-mentioned value categories. In other words, gender has no influence on the values maintained by the teachers. Thirdly, the urban and the rural schoolteachers differed significantly in their moral and economic values. The urban schoolteachers are having higher moral and economic values than the rural schoolteachers. Hence, the location of the schools influences teachers' values. Fourthly, the type of management, private and government influences teachers' values especially their social and theoretical values. The study also revealed that the teachers of boys' school were having higher moral, theoretical, political and economic values. The co-education schoolteachers were having lower religious, theoretical and economic values than the teachers of boy's schools. Hence the type of schools influences teachers' values. The level of education of the teachers had no influence on their values. The values of teachers were not influenced by their length of teaching experience. This study provides a lead for further research in terms of teachers' values and categorization of values.

Usha Sri (1995) presents details of series of studies taken up by her in teaching value education to B. Ed trainees. The activities included, teacher trainees' perceptions of their values system, their self-concept in relation to their values, trainees identifying the values that would be inculcated through various co-curricular activities, participation in seminars, analysis of subject textbooks to identify values depicted through the lessons, etc. It can be seen that the studies conducted on values in education varies widely in its focus from value inculcation among children, teaching experiences to teachers' perception of values. But, the aims of education and value inculcation can be realised only when they are reflected in each and every subject discipline that

forms the part of the school curriculum. Whenever inculcating values through school subjects becomes a topic of discussion, the subjects those mainly come to one's mind probably are languages and social sciences. These are considered to be appropriate platforms to focus on values through the teaching-learning process of the same. The convectional views about mathematics and science being value-free and not forming right platform for the focus on values have now subsided. Recent researches conducted all over the world have now shifted focus on looking at values in mathematics and science education. However, review confirms that the attempts made to study the value aspect of mathematics and science education is limited. Moreover, in the field of science education is negligible.

Values in Mathematics Education

Mathematics is considered to be closely related to Science. It was also viewed as a value-free subject very similar to science. This relationship compels one to examine the studies conducted in the area of values in mathematics education. Despite that mathematics has been viewed to be neutral and value-free, and that mathematics in school should likewise be taught in a neutral way, a number of authors like Bishop (1988) and Ernest (1991), have remarked on the significance of values in mathematics curriculum.

> The recent developments in research on enculturation Bishop's (1988), research with aboriginal students by Harris's (1991), and researches on ethnomathematics by Powell and Frankenstein's (1997) have brought the issue of values into greater focus. Number of studies have been recently conducted in the area of values in mathematics education, recognizing the importance of different sets of values that are found to be portrayed in mathematics classrooms, textbooks etc. This is mainly because school mathematics is intimately linked to the society in which it is taught. Whether we are preparing students for meaningful life in the society or for productive contribution in the workplace, relevant societal values are involved. In the book on enculturation by Bishop (1988), there is a chapter on the values underlying western mathematics. In another study Clarkson (1991) discussed issues of values embedded in different cultures and their implications for mathematics learning.

Though the notion of school mathematics as value-laden was increasingly recognized, a comprehensive review of the affective research literature by McLeod (1992) failed to find any research focussed on values. The tone of his discussion however made it clear that ideas about both beliefs and attitudes towards mathematics do relate to the deeply held values of both teachers and students.

However, Seah and Bishop (2002) showed that there is little explicit discussion with respect values in the classroom. They further found minimal effort by teachers in relating values, mathematics and society. Further they suggest how connections amongst values, mathematics and society may be made. This relationship amongst values, mathematics and society has also been found to be the source of cognitive dissonance amongst immigrant teachers of mathematics in Victoria (Seah, 2002). Even though (or perhaps because) the immigrant teachers were experienced teachers of mathematics in their respective home countries, their respective socialisation experiences in the Australian mathematics classroom are not short of value differences. Although the mathematical aspect of the teaching content is similar across the home countries and Australia, these teachers encounter value differences which are grounded in the ways with which mathematics as a discipline is perceived in Australia, and with which pedagogies differ (e.g. teacher-centred versus student-centred teaching). The role of the society in shaping these different perceptions of values and practice is evident.

In course of exploring values in mathematics, Bishop (1996) identified three categories of values of interest – the general educational, mathematical, and specifically mathematics educational. He found that together, these values were portrayed through the operating functions of teachers, textbooks, syllabi, etc. Beyond mathematics classrooms, values are said to be situated

in increasingly higher contexts of personal, institutional, epistemological, and societal values. These are usually accompanied by a range of (more implicit) peripheral values, which include the implicit message portrayed by for example, the teachers' dressing (Neuman, 1997), textbooks' physical design etc. Beyond mathematics classroom, values are situated in increasingly larger contexts of personal, institutional, epistemological and societal values. Eckermann (1994) in his study has attributed similar factors to influence the teachers' teaching philosophies. Similar categories of values have been discussed with reference to science education variously as 'epistemological and supporting values' (Tan, 1997) and 'Values of science and research ethics' (Allchin, 1999).

In the area of textbook analysis for values, Fauvel's (1991) analysis reveals that values were consciously and actively built into the text through skillful incorporation of such techniques as teaching through dialogue, adopting a didactic catechism style, and reflecting on the links between the historical past and the current methods and instruments. A study conducted by Seah and Bishop (2000) revealed that, mathematical and mathematics educational values are viewed as being influenced by and acting on different socio-cultural levels of values. The data compiled from the content analysis revealed an unbalanced portrayal of various values.

While some learning outcomes on values are explicitly taught by teachers or represented in textbooks, (e.g. valuing mathematics as an important school subject, or appreciating logical reasoning and proof as a specific kind of argumentation) other values are only implicitly taught and remain rather hidden, imbedded in classroom practices. It is obvious that, students learn different values from different teachers' practices and that these values impact on students' engagement with school mathematics and with their mathematical activities. Though, values were not the focus of the Learner's Perspective Study by Keitel, (2003), but during data collection, it emerged in some of the interviews in which students commented on the video of the past lesson. The results of this study showed that the explication of values, however, could contribute to the interpretation of classroom practices and outcomes. Values were gained by side-remarks that some students either started with when commenting on the lesson or deliberately used to interrupt their other comments. These parts of interviews reveal personal and collective values developed in classroom practice. In particular, they show a common, but diverse struggle to make sense of mathematics and relate mathematics to problems of assessment and achievement. They demonstrate that the "same" teacher's script is very differently understood and experienced by students, and that there are also commonalities and differences in inventing ways for living with their struggles.

As a part of the Values and Mathematics Project (VAMP), in order to find out whether mathematics teachers are able to actually focus on values explicitly in the mathematics classrooms, Clarkson, Seah, Bishop and FitzSimons (2000) collected data from classroom observations emphasizing on working with eight volunteer teachers to clarify the relationships between their intended and implemented values. Throughout the process the teachers were encouraged to identify the role that values teaching plays in their classrooms, and how they were implementing those. Data were collected through videotapes, field notes taken by the researcher during the classroom observation and a follow-up interview conducted with each teacher. In analyzing as case studies the teaching of eight teachers, they categorized whether teachers did, or did not, nominate the values that were subsequently observed (or sometimes not observed). Where teachers were observed to teach the nominated values, a conscious decision by the teacher could have been made to address them explicitly (e. g., "today we are going to focus on co-operation…"), or implicitly (e. g., by rewarding co-operative behaviour without mentioning it explicitly). More interesting finding from the study was that values were not nominated by teachers but subsequently observed. Transcript of the data revealed that sometimes teachers

were aware of the underlying values but, to the extent that they had internalized them, they had not considered them worthy of mention.

Researches on Values in Science and Science Education

Values in Science and Technology

Many traditional scientists and researchers consider scientific study a "value-free" practice of investigating fact through objective measurement and impartial use of scientific method. Our educational systems are largely to blame for this feeling of science, and with most scientists not seeking a public voice, they themselves don't give public a chance to better understand the values and social impact of science. Science, too, like all other subjects is a value system, perhaps a more extensive one than scientists themselves acknowledge.

In *Science and Human Values*, Bronowksi (1956) shows the values foundations from which science grows, and describes its essential quest to help humanity. In a statement appearing to contradict a humanist position, he asserts science has succeeded because "man masters nature not by force but by understanding." The values of science derive not from its thoughtful members or from tradition, but from its very practice, which is the "creation of concepts and their exploration in the facts."

Bronowksi identifies several key values constructs found throughout science in history and practice. In particular he identified truth, honesty, respect for human dignity, trust, creativity, independence, sharing, and love of natural beauty and order as values apparent in scientific practice. Underlying this practice, he claims "first, comes independence in observation and then in thought, independence, originality, and then dissent."

Values, Moral Issues and Social Issues in Science Education

Science educators have not addressed adequately the issue of values in science in the past. Poole (1995) made one of the huge contributions to the knowledge on values in science. However, there were few studies conducted, which focused on some aspects of values in science.

Zeidler and Schafer (1984) examined how science content knowledge, moral reasoning ability, attitudes, and past experiences mediate the formation of moral judgments on environmental dilemmas. The study was conducted on environmental science majors and non-science majors of college age. It showed that science majors did not reason at higher levels than non-science majors on a scale called the general measure of moral reasoning (DIT^3), and there fore likely did not possess superior moral reasoning abilities. They however, did exhibit higher levels of moral reasoning than non-science majors in responding to non-technical environmental issues (EIT^4). Associated with those higher reasoning levels, science majors exhibited more positive attitudes towards the environment and a greater commitment to and comprehension of ecology than did the non-science majors. The results suggested that the reasoning used in resolving science-oriented moral dilemmas depends not only on general reasoning ability but also on attitudes, commitments, and comprehension. The researchers suggest that the Science teachers therefore should endeavor not only to help students to acquire a meaningful understanding of subject matter, but should also strive to help them to develop positive attitudes, a care and concern for science-oriented social issues, and a commitment to the resolution of actual issues.

Any concern with values in the classroom is not a substitution for facts and concepts or scholarly orientation towards a subject. Unfortunately, some educators concerned with values at elementary and secondary levels have fallen victim to the indefensible stance of emphasizing valuing and teaching of values at the expense of teaching a subject. In fact, at least one study involving valuing (Dispoto, 1977) at the university level clearly indicated that students better

informed about environmental problems are more likely to be environmentally more active. Humanities majors and science majors are equally concerned about the environment, but science majors do know more about it and do more about the problem. Environmental knowledge is the most powerful predictor of environmental activity and hence of valuing because action demands choice.

Values, Moral Issues and Social Issues in Science Curriculum

Science education continues to undergo a critical examination in all the aspects. Science education has, traditionally, been associated with a formal academic type of schooling, with an intention to produce future scientists, a number of articles and reviews have critically questioned whether this is sufficient for the needs of both society and the citizens who are part of that society (Millar & Osborne, 1998).

A report in England and Wales, *Beyond 2000: Science Education for the Future* (Millar & Osborne, 1998), concluded that the National Curriculum for England and Wales had failed to meet the needs of contemporary society, much less anticipated the needs of future society. The authors acknowledged that 'the changing curricular position of science has not been accompanied by corresponding change in the *content* of the science curriculum . . . This has remained fundamentally unaltered and is, essentially, a diluted form of the previous curriculum of 1960'. The report goes on to give ten recommendations, which include that there should be more emphasis on technology and the applications of science; greater attention should be given to the social processes used to generate, test and scrutinize knowledge claims; teachers should employ a wider range of teaching and learning approaches, including the use of case studies of historical and current issues; new and broader approaches to assessment should be devised and implemented in order to focus attention on the more important aspects of learning. However, as Hodson (2003) points out, "Throughout the document, the case for the importance of scientific literacy (largely defined in terms of conceptual and methodological knowledge, with some socio-cultural dimensions) is strongly and repeatedly made, thus reinforcing the view of some critics that this is yet another attempt to rescue a conventional science education in crisis rather than a commitment to radically reshape the nature and purpose of the curriculum."

Hodson (2003) examining the science curriculum from a Canadian perspective, with an objective of dealing with issues of global concern, stated, referring to a Cannadian curriculum report in largely positive terms, "it is interesting and extremely disappointing that a document purporting to be action-oriented does not include preparation for sociopolitical action by students in its definition of scientific capability". Hodson suggested necessary changes to the science curriculum in terms of gearing it to the socio-political action, which equips "students with the capacity and commitment to take appropriate, responsible and effective action on matters of social, economic, environmental and moral-ethical concern". This view is also shared by researchers like Roth and Desautels (2002). Finally Hudsons comments that traditionally, science education has dealt with established and secure knowledge, while contested knowledge, multiple solutions, controversy values and ethics have been excluded.

Aikenhead (2003), in his review of research on humanistic perspectives in science curricula, concludes that students do positively respond to and can learn usefully from humanistic science curricula but appropriate contexts and atmosphere has to be generated for this to happen. He observes that relevant contexts alone do not ensure more learning of science but more explicit value instructions and the assessment regarding humanistic content, the better the learning, but the greater the challenge to teachers and teaching. In his discussion of the implications of the research, he remains concerned over the fundamental dilemma whether science courses should serve humanistic ends or whether they should continue to focus more

on the knowledge aspects of science. Aikenhead suggests an amalgamation of the educational and scientific goals (focus on both values and content of science) to ensure that real progress.

On the one hand there is a debate about the future purpose of science education and whether it should be viewed largely in terms of creating a suitably trained workforce, or a critical thinking citizen. On the other hand, there is a continuing examination of what learning and teaching strategies are considered to be effective. However, while there appears to be some common themes relating to pedagogy emerging from the literature, it is important to recognise that classrooms and schools are complex environments each of which can be very different, in terms of social mix, general ability, teacher understanding, attitude and values, school ethos etc. The unique combination of these factors can make use of prescriptive pedagogies unreliable. The approach adopted has to be appropriate to the unique environment of each classroom and the aptitudes of the teachers and students in that classroom. It is also the case that the pedagogies employed will be largely determined by the nature of the curriculum proposed.

Values, Moral Issues and Social Issues in Science Textbooks

A number of leading scientists and science educators have identified a need for greater emphasis on social issues and for greater social awareness in high school science. The textbook has been identified as 'the curriculum' in science courses (Stake & Easley, 1978), so it is primarily to the textbooks that we must look for indicators of change. In America, the reform curricula of the late 1950s and the early 1960s, represented in biology by the Biological Sciences Curriculum Study (BSCS), have been criticized for failing to increase student interest in science (Welch, 1979), for giving too little attention to personal and social issues (Hurd, Bybee, Kahle, & Yager, 1980), and for omitting interdisciplinary and transdisciplinary problems (Dede & Hardin, 1973).

Analysing six state-adopted high school biology textbooks for the presence of twenty-five bioethical issues, Boshmann, Hendrix, and Mertens (1978) found that, the issues that are treated most often by all textbooks are those that have been with us for some time. Among those are population, food and famine, pollution, and energy. The newer, more controversial issues such as abortion, family planning, genetic screening and counseling, and recombinant DNA, which represent more complex ethical and moral questions for all. But most of the textbook authors have shied away from these issues. They found that the text books did not sufficiently focus on moral and ethical issues in biology that are very necessary for the students to learn and understand.

In another study, Levin and Lindbeck (1979) analysed the treatment of eleven moral and social issues in five biology textbooks. The specific criteria included under each issue or problem were identified in the literature of science and science education and validated as to appropriateness by several college biology teachers from different institutions. They concluded that, "textbooks differ considerably in their treatment of controversial issues and problems". Consequently, teachers cannot depend solely on textbooks as sources for the study of social issues, but must enrich the curriculum in this area on their own initiative.

In a similar but elaborate work of Rosenthal (1984), she analysed twenty biology textbooks published over twenty years before 1984, for twelve categories of social and moral issues in the textbooks. She found that although increasing attention has been given in recent years to bioethical issues and to the importance of bringing these issues into high school biology (Kieffer, 1979, Stahl, 1979), in these biology textbooks, ethical questions have been raised or implied in connection with only a few topics (destruction of wildlife, control of human genetics, racial superiority, care of terminally ill, distribution of food, and control of human behaviour). Even the most recent textbooks gave little recognition of the ethical implications of biological problems and discoveries. It was found that even when the textbooks did include material related to social

and moral issues, almost no explicit recognition was given to the controversial nature. Similar observations were found in some studies on primary school biology textbooks conducted by NCERT (1996, 1999).

Some biologists argue that they already have incorporated value education in biology course. Franke (1980) opines that the teaching and learning allegedly accomplished in the name of values education are inadequate. Merely mentioning in the classroom contemporary issues in the textbooks does not serve the purpose. The classrooms that are vaguely related to basic biological facts and concepts donot lead the student into valuing experience related to the facts and concepts. Franke (1980) analysed some of the introductory biology textbooks of New York schools on such issues. He found that the 1979-edition biology textbooks stress biology as an objective study, that at best produces fast approximating truth thus forcing the introductory biology student to learn that biology is not necessarily value-oriented. Accordingly, out of the seven textbooks reviewed, except two textbooks (*Contemporary Biology* by Clark, 1979 and *Biology* by Curtis, 1979), which contain several chapters that could be adapted to value discussions, all other textbooks lend little support to the teacher attempting to use the written material in the classroom in teaching of values. Example, *Inquiry into Life* by Mader, (1979), and *Biology* by Arms and Camp, (1979), touches value issues and valuing only in one chapter each, which deals with contemporary environmental problems. Only a skillful teacher could use these areas in both books in a value-oriented session in the classroom. It can be seen that the failure of many biology textbooks to deal with values efficiently is in a stark contrast to the opinions of Harmin, Kirschenbaum, and Simon (1970). They stated, "We have argued for an approach to science teaching that would focus upon values. We have witnessed scientists with too little sense of responsibility for their art and craft too long. It seems incomprehensible to us that science teaching should remain so stubbornly value-free. Just the opposite is needed if science is to help us survive! We need science with responsibility. We need science with a willingness to grapple with the complexities of social issues. Science cannot afford the luxury of business as usual in this day and age". Although the quality of treatment of moral and social values varies from place to place and textbook to textbook, in general the treatment of science and society in high school biology textbooks minimizes the controversial aspects, avoids questions of ethics and values, lacks a global perspective, and neglects the interdisciplinary nature of problems.

As seen above, most of the studies conducted on the issue of values mainly cover biology portion of science. Studies looking at values in other branches of science like physics and chemistry are almost negligible. However, there are a few studies concerning the values manifested in the goals and objectives of science curriculum (not demarcated as physics, chemistry, biology etc) in general and textbooks in particular. In fact, as Harms and Yager (1981) put it, 'science textbooks are widely used in science courses, thus they convey a great deal of the scientific information that the students receive. They also influence how students perceive the scientific enterprise'. Hence, it is necessary that the science textbooks are effectively evaluated and analysed. Few studies, which attempted to analyse the textbooks in science, did not include the value dimension. For example, Mukhopadhyay (1983) on the basis of the content analysis of science textbooks developed an achievement test to measure students' achievement at the primary level. The analysis did not take into account the value aspects of science.

Ramanathan and Siddique (1994) analysed NCERT science textbooks of upper primary level for their representation of scientific concepts and found that the textbooks gave maximum importance to facts and little or no emphasis to the thought process that operate in science or interaction of science, technology and society. NCERT (2000a) content analyzed Class IX and X science textbooks. It concluded that the textbooks for both the classes were 'heavily loaded with the knowledge aspect which makes the student develop conception of science as a body of

facts and truths which are immutable and absolute, as against tentative, probabilistic, humanistic and holistic nature of science'. Such studies hardly go beyond the content to look into values as embedded in the science education.

There are two relevant studies on curriculum and textbooks, conducted by NCERT. The first is on Fundamental Duties and Value Orientation in NCERT Curriculum and Textbooks (NCERT, 1999). It is a detailed study of NCERT's curriculum and textbooks in science, social studies (history, civics and geography), environmental studies (social studies and science) and hindi on coverage of fundamental duties. The report mentioned that the contents of the books were directly related to the Article 51A (h) of the Constitution of India, which deals with development of scientific temper, humanism, etc., and Article 51A (g), which deals with development of sense of protection and improvement of natural environment including forests, lakes, rivers, wild life and to have compassion for living creatures etc. It also found that the science textbooks provided coverage to the above values. The second study is by Joneja (2001), a project on Education in Human Values: An Analysis of Science Textbooks. This study was aimed at analysing the upper primary science textbooks to determine the values emphasized in them. The results indicated that the science textbooks prepared by NCERT for the upper primary stage reflected the values expected to be represented in the textbooks according to the National Curriculum for Elementary and Secondary Education – A Framework (1988). These values include, *curiosity, creativity, objectivity, honesty, equality of sexes,* etc. It was also found that the emphasis on different values varied and it depended upon the nature of the content and topic. There have not been many attempts in analysing science textbooks in other countries. Many other studies have been done involving analysis of school level science texts but they are rarely focused on value aspects of science education.

Values, Moral Issues and Social Issues in Science Classrooms and Science Teaching-Learning Process

As said earlier, a commonly held view, of science as amoral in nature, explains the paucity of studies exploring the role of values in science education, whereas, there exists a vast body of literature on the role of values in social sciences and language. But these studies do not have much bearing on the present field of inquiry. At best the studies on mathematics can be helpful in ascertaining the role of values in science education. However, a few studies have been undertaken on some of the related fields on values in science education. Though not directly related, is seen to have some indirect bearing on the present study are reviewed below.

Some scholars have attempted to identify the values present in science. Abruscato (1972) identified seven values as *truth, freedom, skepticism and originality, order and communication*. In an attempt to locate the values in science and deliberating on the liberal education values of science, Kline (1975) used one word '*rationalism*' to stand for all values such as *critical attitude; independence of mind; open-mindedness, a reasoned approach to problems; willingness to look at the facts either as a test of beliefs or as support for beliefs; and a sympathy for strange ideas*. According to Fox (1966), the values that categorize the enterprise of science are: *Longing to know and understand; Questioning of things; Search for data and their meaning; Demand for verification; Respect for logic; Consideration of premises; and Consideration of consequences.* According to Brown and Brown (1972) "*scientific values*" may be perceived in terms of the norms of the society, or in terms of certain characteristics of the persons involved. However, it was found that they are perceived or expressed, explicitly in the doctrines of scientific method or implicitly in the everyday behaviour of men of science; scientific values, as such are deeply rooted and therefore, profoundly influential in an individual's decisions on both small and grand scales. Such studies show that the science as

a subject is not value free. Bronowksi (1956) takes a romantic view of the discipline, arguing that the values of science are pure and desirable, and should be transmitted to the general public.

In fact the people involved in science like scientists, science teachers and others are said to possess their own personal value structures related to science, which get directly or indirectly transmitted to the people they work with. Handley and Bledsoe (1968), found that while science-apt students acquire the values of scientists, the teachers whom they identify as influential have values different from others teachers and from the students themselves. Rothman (1973), through his study reported that student achievement is more closely related to the personalities and the value systems of Havard Project physics teachers than any other key factor, such as teacher's knowledge, education, or experience.

There are also a few attempts to study the personalities of persons involved in science with regard to the values they have acquired and in order to understand values in science. With a view to delineate of scientists' personal value structures, Brown and Brown (1972) prepared a 'scientific values semantic differential instrument' which included a set of ten value concepts selected as relevant to the domain of science. For this, scientists with various specializations were interviewed on their value-perceptions, responses were analysed to derive common value concepts. These value concepts were c*ause and effect, commitment and persistent, creativity, curiosity, experimental verification, integrity, intellectual and personal honesty, objectivity, open-mindedness and skepticism*. In a study on scientists, Roe (1961) pointed out some distinctive values, which the scientists possess like, independence, self-sufficiency, high autonomy and dominance, preference to resolve disorder, high tolerance for ambiguity, strong egos, valuing interpersonal relationships, ungregarious, asocial, disliking emotionality, valuing risks involving nature but not people etc. The profile of scientific personality presented in Roe's (1961) study gets support from the findings of Rokeach's (1973) survey on values of science teachers as compared to the general public. Terminal values of science teachers reported in the study were an exciting life, a sense of accomplishment, world of beauty, freedom, inner harmony, nature love, self-respect and wisdom. The instrumental values included capability, imaginativeness, independence, intellect and logic. Welch (1973) reported similar results on values of science teachers. According to Vaidya and McIntyre (1998), the human dimension of science might be best understood by a study of men and women in science, whose lives exemplified qualities that contributed to their special role in scientific enterprise. They also emphasise the role of teachers in imparting such values to the children. These studies insist that the teachers need to develop in their students an awareness of safety issues in the science classroom, the laboratory and fieldwork. Equipment and chemicals must be managed safely and confidently for students to conduct science investigations. Teachers need to raise issues of ethics and values related to the care of animals, resources and the environment, so that their students become responsible practitioners of science.

Though the studies of these kinds are very interesting they are mostly theoretical analyses with little empirical support. There is evidence that students do acquire the values of scientists and science teachers but there are no studies on what values the teachers intend to transmit and what are actually acquired by the students (Handley & Bledsoe, 1968; Rothman, 1973).

Emphasizing the need to orient pre-service teachers regarding how values can be transmitted during the teaching-learning process, Vanaja (2003) conducted a study on 65 student-teachers, who opted for physical sciences as one of their methods of teaching, in order to assess the extent to which the student-teachers were oriented towards imparting values through science education. Student-teachers were first exposed to a comprehensive orientation to value-based education and were also provided with a list of values and sample lessons. Assessment was

done on the basis of their internship lessons. It was found that student-teachers, as a result of such orientation, incorporated values in at least three lessons during their internship, started showing interest in value-based education, expressed their willingness to implement value-based teaching in other subjects and even to propagate the concept of value-based education. This study shows the importance of orienting the student-teachers towards imparting value to their students in the process of teaching and how this could be done in science education. Teachers so oriented are more likely to focus on imparting values to their students in the process of teaching learning. An important aspect to be noted here when we talk of imparting values is that values teaching is not an inculcation of an instructor's values in his or her students. Because it involves constructing situations in which students are led to see alternatives more clearly and are allowed to make choices based on a rationale, most traditional approaches to teaching values may not be very useful. Such approaches include inspiration by a moving or emotional demonstration, suggestions that certain rules and regulations are the criteria to be followed because they are right, presentation of cultural or religious dogma as unquestionably wise, or appealing to the conscience through guilt (Raths et al., 1966). It is therefore necessary to check what kind of methodology any teacher is using to transmit values to the students and also whether that is a suitable one, though may not be the focus of the current study.

Very little research work has been done with regard to transmitting values through science and science education. It is also seen that if at all values are transmitted through science education, it is mostly done implicitly. Explicit focus on values by science teachers is seen to be rare. A very recent study by Ratcliffe (2007) explored the difficulties many teachers have in explicitly discussing values within their classrooms. He makes a case for the need for a shift in pedagogy from one that focuses on content to one that examines processes like decision-making etc. Such a shift in pedagogy would necessitate a shift in suitable 'measures' for demonstrating student achievements as both the dominance of summative assessments and their reliance on written forms. This means that the nuances of students' abilities to reason, argue and defend values judgments are rarely captured. Ratcliffe suggests that more explicit discussion of values in science classrooms may be assisted through the use of consistent framework for summative and formative assessments as well as classroom tasks.

As seen from the review above, it can be said that at all the levels (elementary, secondary, or university), attempted value education seems to have been incorporated into the teaching of social sciences and literature. It has seldom been a significant concern in the teaching of science. Such a lack of interest or activity in teaching about value questions in teaching about value questions in science classrooms seems especially remiss in an age when some of the most pressing social questions are to be related both to the present knowledge and to the research frontiers in science.

Key Issues

Culture is "an organised system of values which are transmitted to its members both formally and informally" (McConatha & Schnell, 1995). It is reasonable, then, to postulate that despite similar, canonical form of school science being taught in different educational systems around the world today, its nature and content in any one culture actually reflect that particular culture's outlook towards, and interpretation of, life events (Nunes, 1992). In other words, like many other school subjects, school science is value-laden, as shown through various studies.

There is generally acknowledged to be a close relationship between values and attitudes, with values occupying a more central and deeply held position than attitudes. These are often considered to be reflected in our patterns of response to particular situations (Rokeach, 1973; Seligman, Olson & Zanna, 1996). However, it appears that research in the area of affective

dimension in general, and values in particular, have been both relatively recent and scarce. This is due in part to rather fuzzy understandings of, agreement with, and distinction among the various affective variables such as attitudes, beliefs and values (McLeod, 1992). To make matters worse, related terminology has also been used interchangeably. The word 'value' itself also has several different meanings (Seah, 1999; Swadener & Soedjadi, 1988). Another contributing factor is that the reliability of affective studies has generally been questionable in the academic field (Southwell, 1995).

The affective dimension, however, is but one of the components of educational outcomes, the other components being the cognitive and psychomotor dimensions (Krathwohl, Bloom & Masia, 1964). There have been some science and mathematics educational studies on what Raths, Harmin and Simon (1987) call value indicators, such as interests, attitudes and beliefs. However, a number of such studies have exposed inconsistencies between value indicators and subsequent teacher decisions and actions (Thompson, 1992). This then brings into focus a greater need to examine values, which represent a more influential affective force.

The affective dimension of the Bloom's taxonomy views values as representing the internalisation of value indicators through the valuing process. Values in science education, then, are the deep affective qualities which education fosters through the school subject of science. They represent an individual's internalisation and 'cognitisation' of affective variables (such as beliefs and attitudes) in the context of the culture of the community in which the individual finds himself/herself. They are inculcated through the nature of science and through the individual's experience in the science classroom. These values equip the individual with cognitive and affective lenses that shape and modify his/her way of perceiving and interpreting the world, and guide his/her choice of course of action. Previous research by Buxton (1981) and Fasheh (1982), indicate this in relation to mathematics teaching practices, while Martin (1988/1997) shows how values can enter into the mathematical modelling process. But such observations in case of science teaching are missing due to the clear absence of studies related to values in science and science education.

However, just the realisation that science teaching is as value-laden a school subject as any other has not meant that there are any clear ideas about how such values are taught. In fact it can be stated categorically that there is dearth of empirical research on values teaching in science. There is a clear absence of studies focusing values in science education, science curriculum and the entire teaching learning process.

Specifically, among subjects offered in schools, science and mathematics have not enjoyed as much attention of researchers in affective issues as some other subjects, such as the languages, literature studies, physical education (Aplin & Saunders, 1996). It may be that these other subjects deal with aspects of life experiences more directly and more explicitly, so that values can be easily associated and/or discussed within them. Science, on the other hand, often deals with abstract entities and ideas, and with how these are applied to real-life situations. Values in science, then, are a relatively more implicit conception. Do values exist only implicitly or are they transmitted explicitly or both? Only studies intended towards finding the place of values in science and studies on whether the value focus in science education occurs implicitly or explicitly can clarify the confusions surrounding the nature of value focus in science education.

While there is a growing recognition of the need to address the moral and ethical issues which people are confronted with as a result of scientific progress, evidence suggests that many science teachers do not feel comfortable, nor equipped to deal with such moral and ethical issues (Levinson & Turner, 2001; Bryce & Gray, 2004). Knowing how to handle discussion and debate in the class is an area, which needs to be developed in the science classroom. Research points out the importance of teaching science in real contexts in order to engage students' interest,

to increase the relevance of science to students' lives, and to help students develop better understandings in science and about science (Jones & Baker, 2005). Carter (2005) and Hodson, (2003) recognize the importance of the local and global implications of science issues related to the moral, ethical and social aspects of science as being important for the development of scientific literacy and citizenship skills. They provide real-life contexts for the study of scientific knowledge as well as providing relevance and motivation for the students engaged in their study.
Science is values-laden and perhaps the best thing to be hoped for is a balanced class in which variety of opinions are considered. The social, scientific, and technological problems we face cannot be solved by knowledge alone, as if the values issues they contain had absolute answers. Science classrooms must suggest the consequences of certain choices, and to do that it must consider values. To ignore values questions means that they will be dealt with elsewhere, in a setting where science's input is absent. Hence studies on various aspects related to values in science and science education are an immediate requirement.

It is seen that the values occupy a very primary interest of several researchers. As evident from the review, values educators encourage children to express themselves freely so that they may come to understand their own values as well as those of others, thereby developing more mature forms of moral reasoning. They point out that values are pervasive; that science teachers, too, represent a special value system, which is transmitted implicitly or explicitly, to their students. Most of the findings of the studies mentioned in the review are shown to have yielded positive results endorsing the beneficial and developmental role played by values in education by teachers at different levels of education, in various subject areas, etc., formally or informally. But, there is a clear absence of studies that could answer questions like - what kinds of values are focused upon in the science curriculum; are they effectively transmitted to the students though the curriculum and teachers; if they are transmitted how they are done.

The studies with respect to teachers' and students' understanding of values in science are almost absent. Much of the literature suggests that many teachers' understanding of the nature of science is implicit rather than explicit, sometimes naive and at odds with established wisdom and understanding. Thus it is seen that the way in which science is portrayed to school students focuses very much on science as a body of "facts" and a methodological approach and very often fails to address the tentative nature of science, uncertainty and unpredictability in science and the way in which values, attitudes and cultural perspectives can influence both the practice and interpretation of scientific activity. Therefore preliminary studies that reflect on the teachers' as well as students' understanding of values in science are necessary so that relevant curriculum, policies and training methodologies for value inculcation through science education can be developed.

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