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Scientific Culture, Multiculturalism and the Science Classroom

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ABSTRACT. One possible way of encouraging underrepresented groups to participate in science is to ensure that science is seen to be inclusionary. To this end a distinction is made between science (as knowledge) and scientific culture. A description of how one obtains membership in that culture is provided. Including the contributions of many different groups to scientific culture, when teaching the history, philosophy and sociology of science, is one way to emphasize that everyone can do science; something critical in multicultural science classrooms.

INTRODUCTION

In the newest curriculum guideline in Ontario, one learning outcome to be attained by all students by the end of grade 9 is that they be able to:

> use statistical information to identify groups of people (e.g. women, racial/ethnocultural minorities, disabled persons) who may be under-represented in careers in mathematics, science and technology, and discuss ways of eliminating such inequities. (Ministry of Education and Training 1993, p. 93)

While such an outcome is laudable, reaching it is no easy task for researchers, let alone students. Oakes (1990) reported that Hispanics and Blacks each represented about 2% of the scientific workforce in the United States. (The numbers representing what proportion of the U.S. population is Hispanic or Black are unfortunately not provided for comparison purposes.) Krugly-Smolska (1993) after a special request for data from Statistics Canada, reported that within science and technology careers, after the Anglo-celtic and the French, Orientals were significantly more represented than any other group, while the Hispanics/Blacks were significantly below all ethnic groups except Native Canadians.

But statistics are not always necessary. Students need only to look at the science teachers in their schools and at their professors in university to see who is and who is not represented; or when a poster is produced by a publishing company illustrating famous Canadian scientists and inventors and they are all male and white. The underrepresentation is evident, what is more difficult is to understand why it continues to perpetuate itself.

Many possible explanations investigated by researchers are comprehensively reviewed by Oakes (1990). Most of these are psychological and sociological and deal with achievement. While achievement may be correlated with continued studies in science it by no means guarantees it. Lewko *et al.* (1993), for example, found that high-achieving, highly motivated females who really enjoyed science were still less likely to pursue science than an equivalent sample of males. The results of the studies reviewed by Oakes will not be repeated here, for at the end of it all Oakes concludes that much more research is needed, including work that might focus on societal issues such as family and community socialization.

It is argued here that, in addition, a cultural explanation may provide some answers to the patterns of participation in science. More specifically, it is suggested that when certain groups do not see themselves represented within scientific culture, they are less likely to choose to participate. This may also happen when aspects of the group's culture are seen to be conflicting with those of scientific culture.

SCIENTIFIC CULTURE

Culture is one of those concepts that most of us seem to understand but for which we have difficulty providing a definition. By the middle of this century there were already over 160 definitions as identified by Kroeber and Kluckhon (1963) and there are probably just as many since. For Goodenough (1971), culture refers to the understanding about things and the expectations of one another that the members of a society seem to share. Similarly, Geertz (1983) writes of basic categories people use to make sense of the world and to decide how to act in it, as well as things taken for granted. While such conceptualizations are useful for general understanding, they are not useful for analytic purposes. One definition that is useful to this purpose because of its comprehensiveness, conciseness and precision, is provided by Bullivant:

> Culture can be thought of as the knowledge and conceptions, embodied in symbolic and non-symbolic communication modes, about the technology and skills, customary behaviours, values, beliefs and attitudes, a society has evolved from its historical past, and progressively modifies and augments to give meaning to and cope with the present and anticipated future problems of its existence. (1981, p. 19)

When culture is viewed in this way, that is, consisting of a body of knowledge, communication modes, technology and skills, behaviours, and values, then science can be considered a separate culture. Sociologists of science have provided data that would support this assumption (e.g. Smolicz and Nunan 1975).

The treatment of science as a separate culture appears to contradict the position of Elkana (1981) who prefers to refer to it as a cultural system:

> My basic presupposition is that the various dimensions of culture: religion, art, science, ideology, common-sense, music are correlates, they are all cultural systems. I reject the alternative approach, according to which culture can be viewed as an arithmetical sum of its dimensions which can then be sliced up into Religion, Art, Science, etc. . . . . Any

culture, and Western or European culture especially, can be viewed as the Culture of Science connected with the mystical, religious, artistic, musical, ideological aspects. (p. 6)

The contradiction is apparent only, for it is understood that scientific culture is embedded in a larger culture (in this case Western). While subculture (or cultural system) may be more appropriate, the term 'culture' is used in a similar sense to the way Noble (1992) subtitles his recent book *A World Without Women* as 'the Christian Clerical Culture of Western Science', with the implicit assumption that everyone knows what he is writing about and if not will come to understand from the book. Unlike other cultures, however, scientific culture has developed around a central purpose: to create new knowledge, and specifically knowledge about the physical world. That knowledge is validated or not by the members of the culture (using Goodenough's notion referred to above).

One can become a member of the scientific culture by interacting with other scientists.

They and he [sic] participate in a body of generalised propositions, very concrete particular propositions; techniques and rules of observation and analysis, and the scientific ethos . . . . They also provide him with a body of judgements or opinions about which problems are worthwhile and which are trivial, which methods are more appropriate than others, and which kinds of solutions are more adequate than others . . . To obtain certification and the reward of recognition, a scientist must conform to the standards which are applied by his colleagues. (Schott 1991, p. 441)

It is possible to see the parallels to the definition of culture provided above. It is through this process of scientists interacting with each other that communication modes, values and behaviours are reproduced. It is this process that is referred to when one talks of science being socially constructed. Because of this and the way that membership seems to be determined, scientific culture is often perceived not to be inclusive.

Indeed, it has been argued that one reason that women are underrepresented as members of this culture is that the values and behaviours instilled in them as part of their socialization are contradictory to those valued by scientific culture; or that the problems women consider important to investigate are not so deemed by the male scientific community (Harding 1991). The perception of scientific culture as a masculine culture needs no defense here. Kelly (1987) states:

There are at least four distinct senses in which it can be argued that science is masculine. The most obvious is in terms of numbers – who studies science at school, who teaches it, who is recognized as a scientist. Secondly, there is the packaging of science, the way it is presented, the examples and applications that are stressed. Thirdly, there are the classroom behaviours and interactions whereby elements of masculinity and femininity developed in out-of-school contexts are transformed in such a way as to establish science as a male preserve. And finally there is the suggestion that the type of thinking commonly labelled scientific embodies an intrinsically masculine world view (p. 66).

It is argued here, that wherever Kelly uses 'masculine', 'white' and 'western' could also be substituted. Similarly it can be argued that members of other cultures whose behaviours, values, communication modes, etc., do not correspond to, or are in conflict with, scientific culture may also be underrepresented.

Because the social arrangements, interactions, behaviours, values etc. may be different, as may the problems deemed worthy of investigation, it is possible to speak of a feminist science or an Islamic science (Sardar 1989). Such a position may be problematic for some:

> Somehow, sociologists of science cannot understand that observational powers and the exercise of rationality are inherent in the intellectual confrontation with nature. Observation and the criteria of the validity of observations and the exercise of rationality are not solely the products of culture mediated through social institutions. They are of course influenced by the institutional and cultural setting in which they are aroused and exercised. They are, however, inherent in cognitive or intellectual activity as such . . . I conclude from this that the criteria of validity are not 'culture-bound', even if we mean by 'culture', in this context, the 'culture' of science in general or the 'culture' of any particular science. Scientists in all civilisations seek evidence of validity of observations and consistency of reasoning (Shils 1991, p.398).

Shils argues that scientific knowledge has universal validity. Whether or not that is the case is not at issue here and that debate is left to others (e.g. Harding 1991; Cole 1992; Matthews 1993; Stanley & Brickhouse 1994). What Shils acknowledges is that all civilisations have had scientists. Furthermore, he argues that 'it is important to be cognisant of the fact that indigenous traditions can transmit truths of universal validity' (1991, p. 403). Such inclusion is not part of the scientific culture that is transmitted in schools and may be why certain groups do not envision themselves as members of a scientific culture.

In Oakes' review of females and minorities in science referred to above, Asians were not considered because they were 'overrepresented'. But that very fact needs to be investigated – why do some Asians and Orientals apparently participate more in science and technology than any other non-western group? One possible hypothesis is that scientific knowledge is highly valued in these groups. 'The project of testing and elaborating the theory through broad cross-cultural and historical analyses in which both the value placed on science and the rate of advance are measured remains on the research agenda' (Cole 1992, p. 210).

If indeed participation in science is affected by the value placed on scientific knowledge in one's society, then the participation of Asians and Orientals is not surprising since both have a long historical tradition of scientific and technological endeavour (Krugly-Smolska 1992). Because of this tradition it is possible that members of these groups do not have difficulty envisioning themselves included in scientific culture; the role models are there. It may also explain why females are more represented in science in some cultures than in others, whereas western tradition has historically excluded women from this endeavour (Schiebinger 1989; Noble 1992). The task at hand, however, is to look beyond the past and consider how the groups traditionally underrepresented can be encouraged to participate. The science classroom can be an important catalyst in this enterprise. How this might occur is discussed in the next section.

THE MULTICULTURAL SCIENCE CLASSROOM

As has been argued above, it is important to illustrate to students that science can be for everyone. In order for this to occur, scientific culture must be seen to be more inclusionary. Cultures have boundaries and shared cultural knowledge implies membership. Part of this knowledge includes myths that are characteristic of that culture and are passed on from generation to generation often without challenge. These myths, by their very nature, do not reflect reality. In science, such myths are often passed on in science classrooms and in science textbooks. Consider the following taken from a UNESCO document dealing with the importance of science and technology for national development:

> Primitive religions, folklore and old wives' tales are full of explanations of why things are as they are. Such explanations reflect the human need to know, but they are based on ignorance. And this ignorance, in effect, is a lack of satisfactory means of probing the mysteries of nature. The essence of the scientific method is its concern for evidence as opposed to hearsay. (Morris 1983, p. 37)

It is probable that the majority of science educators would not take exception to the above quote. The last sentence is especially compelling. What is disturbing is the implicit assumption that the explanations from folklore and 'old wives' tales' were not based on evidence. It completely ignores the fact that some of those old wives' tales had 'universal validity' as Shils would describe it and have been confirmed by the scientific community. The problem here is the implicit assumption that knowledge is not valid until the Western scientific community acknowledges it as such. Consider also the following from a text aimed at future science teachers:

> The 16th and 17th centuries marked the birth of empirical science. Prior to this time the philosophy of science was influenced by Platonism and by Artistotle's deductive method. The search for truth was centered in the analysis of universal ideas, and there was little interest in verification through experience . . . . Francis Bacon and Rene Descartes both developed empirical methods. They maintained that there was little need to appeal to authority, for each person could find truth either through careful observation or through the power of intellect. (Trowbridge & Bybee 1990, p. 52)

This is an example of boundary setting. Empirical methods existed long before the 16th and 17th centuries (Krugly-Smolska 1992); what was missing was the institutionalization of validity-enhancing intellectual activity as occurred in the West (Holzner *et al.* 1985). The myth then became that science started with Bacon, when Western science was starting to become dominant. This is problematic when the myth that technology is applied science is added, for technology then existed long before science as we know it. But such contradictions are not uncommon in cultural myths. It should also be kept in mind that there is no personal conspiracy involved in maintaining these myths, they are 'truths' that are passed on unexamined from teachers to students who then become teachers. A statement such as that above is often all the philosophy of science (if one can even call it that) some future science teachers ever get.

Another myth in the above quotation is that each person could find truth through observation without appeal to authority. While this may have been true in the early days of science it is no longer the case, not only because peer review becomes the authority against which 'truth' is measured, but also because science today has moved beyond a strictly empiricist approach. However, it must be remembered that this is not the case as far as school science is concerned (Smolicz & Nunan 1975). This creates a dilemma, for we do want to continue to emphasize that everyone can do science and take a scientific perspective in their lives on an individual basis. By acknowledgeing that science existed and exists in other cultures, especially in those areas that are now considered 'Third World', and by making boundary setting myths explicit, science could become more inclusionary to individuals from a variety of cultural backgrounds. Learning about the history and philosophy (and sociology) of science is central in this process in order for students to understand how western science differs from science in other cultures and why it has become the culture in which most scientists from around the world participate (Shils 1991; Schott 1991). Acknowledgement of other cultures' contributions is one form of inclusion in a multicultural classroom.

Multicultural education as a policy usually includes two aspects: education *for* the culturally different and education *about* the culturally different. In Ontario the policy states that multiculturalism

> should permeate the school's curriculum, policies, teaching methods and materials, courses of study, and assessment and testing procedures, as well as attitudes and expectations of its staff and all their interaction with students, parents and the community. Teachers should be encouraged to develop courses consistent with the educational goals of multiculturalism and that reflect fairly accurately the reality of Canada's multicultural, multiracial society. Principals should ensure that, where relevant, core units exploring the multicultural and multiracial dimensions of issues are incorporated into compulsory subjects. (Ontario Ministry of Education 1989, pp. 9–10)

Education for the culturally different may be inferred from the statement about teaching methods and assessment practices while teaching about the culturally different may be inferred from the call to address the multicultural dimensions of issues. Prior to this statement to talk about multiculturalism in the science classroom in Ontario was not to have an audience of teachers. Even now teachers who do not have English as a second language (ESL) students or students who are visibly from another culture in their classes do not recognize a need to respond to the Ministry directive. On the other hand, given the training most science teachers get, how do they begin? After all, as far as they are concerned, science is acultural. This is considered synonymous with scientific knowledge having universal validity, contrary to the position presented here.

For real progress to occur, science teachers must recognize that no matter how monocultural a classroom appears to be, all science classrooms are multicultural. Not only are the various ethnic background cultures represented, but so are gender cultures, adolescent cultures, the dominant culture, the school culture and scientific culture. At any time any number of these may be in conflict either because of communication modes, values, behaviours or assumed shared cultural knowledge. Students can become even more bewildered when a switch from one cultural context to another is not explicitly signalled. One of the best examples of this is the confusion caused by the word 'work' which has an everyday (dominant culture) meaning different from its scientific (science culture) meaning, and probably a different meaning yet again in adolescent culture. Add to this a student from a different ethnic background working in a second language or dialect and we have real potential for confusion. This is even more important when you consider the widespread use of analogies, metaphors and models in science teaching and, for that matter, in scientific research.

> Meaningful learning involves an active construction of knowledge by the learner. The growth of knowledge is influenced by the language of the learner and, in particular, by the metaphors embodied therein. Metaphorical concepts are as essential to scientific language as they are in everyday language. Students need to be aware of metaphors, and to recognize areas where metaphors conflict or overlap, in order to reconcile everyday knowledge with scientific knowledge. (Hewson & Hamlyn 1985, p. 42)

At the very least teachers should ensure that the examples and analogies they use cross cultural boundaries.

Once teachers have recognized the multicultural context of their classrooms, usually only minor changes in teaching strategies can make their classrooms more inclusionary. 'Entailed in the choice of one pedagogical strategy rather than another is the opportunity to make a culture trait negatively salient or not' (Erickson 1987, p. 353). This includes any purported differences in cognition that are said to be culturally determined. The pedagogical strategies include using a variety of structures for classroom discourse (such as not always having to speak one at a time) and teaching to different learning styles, strategies that are recognized as important in addressing individual differences as well as cultural differences.

Bringing multicultural issues into the science classroom seems to be more problematic. Suggestions of how to do that are available to teachers (Krugly-Smolska 1992b; Hodson 1993). These include the fairly obvious ones from biology where the question of whether or not to dissect arises not just as a result of the animal rights movement but from cultural values held by students. And if a decision is made to dissect, is it appropriate to be dissecting a cow's eye with Hindu students in the class? Issues around health and nutrition also lend themselves readily to cultural interpretation. Genetics allows for discussion about the similarities among humans rather than the differences and the fact that race is not a biological concept. More difficult to see are multicultural issues in chemistry and physics, but these may arise in environmental contexts and in consumer chemistry or industrial physics. The real possibilities arise when students are taught about science in its social context. Therein lies the roadblock, apparently.

Many science teachers still believe that science is the body of facts and theories produced by science and that these can be transmitted to students. These are the same teachers that, unaware and unquestioningly, transmit the culture of science with all its myths. Until prospective science teachers have a background in the history, philosophy and sociology of science, little progress will be made in incorporating science-technology-society education, including multicultural aspects, into the science classroom; and until those aspects are included, science classrooms will not be perceived as inclusionary environments by many students.

REFERENCES

Bullivant, B.: 1981, *Race, Ethnicity and Curriculum*, Macmillan Co. of Australia, Melbourne.

Cole, S.: 1992, *Making Science*, Harvard University Press, Cambridge, MA.

Elkana, Y.: 1981, 'A Programmatic Attempt at an Anthropology of Knowledge', in E. Mendelsohn and Y. Elkana (eds.), *Sciences and Cultures*, D. Reidel Publishing Co., Dordrecht, 1–76.

Erickson, F.: 1987, 'Transformation and School Success: The Politics and Culture of Educational Achievement', *Anthropology and Education Quarterly*, **16**(4), 335–356.

Geertz, C.: 1983, *Local Knowledge*, Basic Books, New York.

Goodenough, W.H.: 1971, *Culture, Language and Society*, Benjamin Cummings Publishing Co., Mento Park, CA.

Harding, S.: 1991, *Whose Science? Whose Knowledge?*, Cornell University Press, Ithica, N.Y.

Hodson, D.: 1993, 'In Search of a Rationale for Multicultural Science Education', *Science Education*, **77**(6), 685–711.

Holzner, B., Cambell, D.T. & Shahidullah, M.: 1985, 'Introduction', *Knowledge: Creation, Diffusion, Utilization*, **6**, 307–328.

Kelly, A.: 1987, 'The Construction of Masculine Science', in A. Kelly (ed.) *Science for Girls?*, Open University Press, Philadelphia, 66–77.

Kroeber, A.L. & Kluckhohn, C.: 1963, *Culture – A Critical Review of Concepts and Definitions*, Vintage Books, New York.

Krugly-Smolska, E.: 1993, A Comparison of Participation in Science and Technology Occupations by Ethnic Minorities: Implications for Equity. A paper presented at the annual meeting of the Canadian Sociology and Anthropology Association, June 6, Carleton University, Ottawa.

Krugly-Smolska, E.: 1992, 'A Cross-cultural Comparison of Conceptions of Science', in S. Hills (ed.) *The History and Philosophy of Science in Science Education*, Vol. 1 Proceedings of the Second International Conference on the History and Philosophy of Science and Science Teaching, Queen's University, Kingston, 583–593.

Krugly-Smolska, E.: 1992b, 'Mainstreaming Multicultural Education: The Role of Science Education', *Canadian Ethnic Studies*, **24**(3), 137–144.

Lewko, J.H., Hein, C., Garg, R. & Tesson, G.: 1993, 'Transition of Adolescents into Science Career Pathways', in P. Anisef & P. Axelrod (eds.), *Schooling and Employment in Canada*, Thompson Educational Publishing, Toronto, 65–87.

Matthews, M.R.: 1994, *Science Teaching: The Role of History and Philosophy of Science*, Routledge, New York.

Morris, R.W.: 1983, *Science and Technology Education and National Development*, UNESCO, Paris.

Noble, D.F.: 1992, *A World Without Women*, Oxford University Press, New York.

Oakes, J.: 1990, 'Opportunities, Achievement, and Choice: Women and Minority Students in Science and Mathematics', *Review of Research in Education*, **16**, 153–222.

Ontario Ministry of Education: 1989, *Ontario Schools Intermediate and Senior Divisions*, Toronto.

Sardar, Z.: 1989, *Explorations in Islamic Science*, Mansell, London.

Schiebinger, L.: 1989, *The Mind has no Sex?*, Harvard University Press, Cambridge, Mass.

Schott, T.: 1991, 'The World Scientific Community: Globality and Globalization', *Minerva*, **29**(4), 440–462.

Shils, E.: 1991, 'Reflections on Tradition, Centre and Periphery and the Universal Validity of Science: The Significance of the Life of S. Ramanujan', *Minerva*, **29**(4), 393–419.

Smolicz, J.J. & Nunan, E.E.: 1975, 'The Philosophical and Sociological Foundations of Science Education: The Demythologizing of School Science', *Studies in Science Education*, **2**, 101–143.

Stanley, W.B, & Brickhouse, N.W.: 1994, 'Multiculturalism, Universalism, and Science Education', *Science Education*, **78**(4), 387–398.

Trowbridge, L.W. & Bybee, R.W.: 1990, *Becoming a Secondary School Science Teacher*, Merrill, Columbus, OH.