Soul, Mind and Science Education

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Abstract

An enquiry is made about the nature of the soul at the dawn of premodernism, at the dawn of modernism and in the era of postmodernism. The enquiry is used to support the view that, even in today's politically correct and morally relativist world, science (and by default science education) should continue to predicate its activity on, and judge its success by, a commonsense appeal to experience, and not give in to lesser forms of validation.

Introduction

This paper briefly and narrowly discusses understandings of the human soul in so far as these can be extracted from the writings of Plato and Berkeley. It also briefly examines present day writings concerning cognition and learning and the importance of metacognition in concept change and development. The discussion is used to put the view that science (and by default science education) should, even in today's politically correct and morally relativist world, continue to predicate its activity on, and judge its success by, a commonsense appeal to experience and not give in to lesser forms of validation.

In general usage the word 'soul' is often employed to denote the spiritual, rational, and immortal dimensions of humankind or the thinking agent in humankind. However, it has wider connotations: intelligence, feelings, fantasy, imagination, understanding, reflection, remembering, self knowledge and noetic recollection. Soul in this paper is understood generally in the sense of perception and loosely as mind, although such usage carries with it considerable simplification and some insufficiency through the anachronistic licence it entails. Although no discussion of soul involving either Plato or Berkeley can be complete without acknowledging its spiritual and immortality dimensions, these are not the focus of interest. To make this claim is not to argue that science (and by default science education) is without its social and spiritual dimensions, or that in safe and civil society it/they (science/science education) should be allowed to proceed willy-nilly without acknowledgment of those wider dimensions.

The issue of truth and soul was alive in pre-Socratic times (Burnett, 1908) but in this paper Plato's *Republic* (Jowett, 2005a) and two of his dialogues, the *Phaedo* (Plato, 2003) and the *Timaeus* (Plato, 2005) are used to illustrate the early origins of the linking of truth and mind. Berkeley's "Essay towards a New Theory of Vision" (Berkeley, 1948) and his "Principles of Human Knowledge" (Berkeley, 1952) are used to discuss a 17th century explanation of the understanding of this coupling. The works of several authors (Flavell, 1976; Hewson, 1982; Hewson & Hewson, 1984; Hewson & Thorley, 1989; Hewson, 1981; Posner, Strike, Hewson & Gertzog, 1982) are used to discuss mind

and truth in present educational praxis. Each brief discussion (Plato, Berkeley and the postmoderns) is in the nature of a single snapshot and the paper seeks to identify nothing more than a theme common to the three: *viz.*, that truth is an important notion in science and by default in science education – a point that sometimes appears lost in radical constructivism and considered too troublesome and difficult under postmodernism.

Because the paper seeks only to make the general point outlined in the opening paragraph, rather than to go more deeply into the nature of the soul *per se*, Aristotle (1952) receives only passing mention, Berkeley is discussed with very little reference to Locke (1975) and no more than passing acknowledgment of Marlebranche (1694), Descartes (1955) and Hume (2005). Likewise, given von Glasersfeld's ironic claim that Locke uses his term 'reflection' with the meaning "that is fundamental in cognitive construction since Piaget" (1995, p. 31) – the interesting implication of this claim is that Berkeley and Hume failed to extinguish Locke – the postmoderns are spoken of separately rather than through their links in the great conversation through Piaget (1979) back to Hume (2005). A more complete discussion would of course redress this and other lacunas.

Three Treatments of Soul

Soul at the 'dawn' of premodernism

Plato was "first among the Greeks" to conceive a method of knowledge even though he "barely distinguished that method from the substance of truth" (Jowett, 2005a, p. 1). Amongst the many other accolades awarded to Plato by Jowett is an acknowledgment of the division of the mind into the rational, concupiscent and irascible elements (2005a, p. 2). In Book Nine of the *Republic*, the soul is depicted as a composite: a chariot and charioteer drawn by two horses – one good and the other bad. The good loves "honour, and modesty and temperance" and the bad is the "mate of insolence and pride". The good is guided by "word and admonition"; the bad hardly yields "to whip and spur". Different interpretations have been given: Plato himself urges a reason and passion interpretation. Augustine (1952) was later to interpret the soul as will, knowledge and memory.

In the *Timaeus* (2005), Plato presents an analogy between the soul of the world and the soul of man. The soul of the world consists of the same (the unchanging) and the other (the changing) – *cf.* the "fixed" stars and the moving planets. God is prior to the world, the soul is prior to body and ideas (forms) are prior to the sensible objects. The "same" in the world soul is the thought of God which gave law and variability to the material copy of that world which has its perturbations and disturbances (the other). In the human soul, reason is the "homologue" of the "same" and passion and appetite of "the other". In this sense, reason works towards bringing order to the chaos. In humankind, the three parts of the soul (the rational, the passionate and the appetitive) are given bodily physiology through head, heart and belly. The composite (chariot) metaphor with its insights into the rational and erotic mysteries of the soul remains powerful in psychology and education to this day. It could be used in modern times to explain metacognition: the charioteer (mind

or will) in moving towards an objective must balance reason and the erotic/appetitive forces and coincidently audit itself at work in this process.

In the *Phaedo* (Plato, 2001), Plato partly explains the pilgrimage of the soul – that series of wanderings and rebirths by which it gains understandings of the forms and successively comes to some grasping of truth through the noesis that the process allows. Thus, for the most metaphysical of the metaphysicians, truth is that thing sought after by the human soul. The nature of the 'science' through which truth was sought in the corrupted real world of objects is discussed in enjoyable detail by Jowett (2005b) in his illuminating "Introduction and Analysis" to the *Timaeus*.

Soul at the "dawn" of modernism

In his *De Anima* (1952), Aristotle was soon to demolish the pilgrimage of the soul, bringing the soul down to earth in a manner substantially different from Plato. In this work of science, the like of which has never been seen since, Aristotle allowed the soul some independence and will of its own in that it was able, through reason, to seek the truth about the real world of material things through the use of a logic not predicated on Platonic noesis. The battle over this departure was continuing when Berkeley (1685-1753) began to develop an immaterialist explanation of the presence of objects consistent with commonsense empiricism (Berkeley, 1948, 1949). Berkeley among the moderns glimpsed the coming scepticism inherent in commonsense access to scientific laws that has been troublesome since Hume (1711-1776) (2005). Locke (1632-1704) (1975) had allowed access to the causal properties of objects through sensation and reflection. Descartes (1596-1650) (1955) had introduced the "I" to explain intuitive knowledge of the soul (self) and urged the duality of mind and body. Hobbes (1588-1679) (1991) had argued that that causation was in the properties of things rather than in God's will.

Berkeley's central explanation of the 'reality' reached through human perception (to be is to perceive or be perceived, or to act or will) is not without its contradictions. For example, Berkeley grants that such reality (his office table, for example [Berkeley, 1952, paragraph 3]) does exist independent of human experience simply because it is continually perceived (or perhaps willed) by God (Berkeley, 1957, paragraph 3). It does not materialise and dematerialise as a function of human perception. Such reality is organised according to the laws of nature, such laws being accessible to humans by virtue of commonsense perception predicated on matter (causal property) which exists only in the form of ideas under the action of spirit. In no sense does Berkeley suggest that humans could invent or construct the laws of nature (especially causation of any kind) in the manner of constructivism. God's regular and permanent laws of nature (and the efficient causes therein) were there for humans to know about (Berkeley, 1952, paragraph 105) through simple commonsense perception. Berkeley's position was one of positive idealism consistent with commonsense access to real objects – objects which continue to exist when not perceived by human intellects.

Some of the contradictions referred to earlier go to the heart of Berkeley's immaterialism. In the "Principles of Human Knowledge" Berkeley denies material but accepts that there

are material substances (1949, paragraphs 19, 37) and that the soul is a spiritual substance (1949, paragraphs 27, 36) but that these substances are not known as ideas are known (Luce, 1944, p. 339). In the "Essay towards a New Theory of Vision" (Berkeley, 1948, paragraphs 46, 64, 99, 117, 155), objects accessible by touch are spoken of as existing without the mind (Flage, 2004, p. 5). In the "Principles of Human Knowledge" (1949, pp. 40, 87-89), Berkeley also allows that there are bodies distinct from the mind but that such bodies are sensible but not material (Luce, 1944, p. 339). Flage (2004, p. 5) suggests that these contradictions may have resulted because Berkeley may have been sometimes speaking in the 'vulgar' or because they are inherent in the difference between the "Essay towards a New Theory of Vision" (thought of by some as a work of science) and the "Principles of Human Knowledge" (thought of by some as highly metaphysical). Luce (1944, p. xviii) explains contradictions of this kind in terms of Berkeley's development of his immaterialist thesis.

According to Berkeley, the ideas upon which the spirit acts are inert, in the sense that ideas do not cause other ideas: this causation is the activity of the spirit. Some ideas arrive involuntarily (immediately) and are active and lively. Other ideas arrive more slowly (mediately) but the process is not well explained. In Berkeley, existing objects are immediately perceived (Pappas, 2000, pp. 147-182). A controversy continues about whether Berkeley allows mediate perception: such an admission would certainly spell trouble for his abstraction argument.

Berkeley's attack on the primary qualities (see Table 1) is part of his questioning of Locke's explanation of abstraction. Under Locke, the immediate ideas generated by primary qualities represent the true qualities (natures) of those objects. The secondary qualities ascertained through mediate ideas were in part ascertained through abstraction understood as that process of obtaining general terms encompassing all of the ideas representing properties common to the term. Berkeley dismissed this and other forms of abstraction (see Table 2), arguing instead that the general term is not abstracted but rather consists of "any one of several particular ideas, any one of which it indifferently suggests to the mind" (Berkeley, 1952, Introduction, p. 11). Following this reasoning, the secondary qualities (mediate or "less true" ideas) are not abstractions of the kind Locke would have them to be.

Table 1: Locke's primary and secondary qualities

Classification	Ideas Generated by the Qualities
Primary Qualities	Solidity, extension, figure, motion or rest, and number (II viii 9)
Secondary Qualities	Taste, smell and sound (II viii 10), colour, heat and cold

Source: adapted from Locke, 1975, II, viii, pp. 9-10

Berkeley's rejection of abstraction is in turn only a part of his larger ontology, *viz.*, the immateriality of perceived objects. This immateriality consists of objects being composed of ideas. Ideas are acted upon by spirit – "simple, undivided, active being" (Berkeley,

1952, paragraph 27) which when perceiving ideas is called "understanding" (Berkeley, 1952, paragraph 27), which when it operates on the ideas is called "will"

Table 2: Berkeley's acceptance and rejection of abstraction

#	Kind of Abstraction	Explanation	Example	Admitted?
1	Simple parts or qualities from various combinations of them	Parts which can exist separately in themselves can be abstracted from an object in which they are combined	A hand can be thought of separate from a body. Berkeley can, for example, imagine a man with two heads	Admitted (Introduction, p. 10)
2	Quality from quality or mode from substance	Qualities perceived together but which cannot exist separately cannot be abstracted	The blackness or whiteness of a particular extension (a person say or a piece of coal or a snowball or the hand in 1 above) cannot be perceived in the absence of the substance. The colour of the hand cannot exist separately from the extension (space occupied) of the hand nor can the motion of a body exist separately from the body itself. Colour and motion cannot be abstracted.	Not Admitted (Introduction, p. 10)
3	General notions or terms	It is impossible to abstract a general notion from the particulars of the many which general notion is then "prescinded" from the particulars	It is impossible to think about (abstract the general term extension) "extension which is neither line, surface nor solid, nor has any figure or magnitude, but is an idea entirely prescinded from all these" (Introduction, p. 8).	Not Admitted (Introduction, p. 10)

Source: adapted from Berkeley, 1952, pp. 405-407

(Berkeley, 1952, paragraph 27), and which when it is acting "cannot be of itself perceived, but only by the effects which it produceth" (Berkeley, 1952, paragraph 27). Spirit is synonymous with "soul" (Berkeley, 1952, paragraph 27; 1957, paragraph 323) and unlike material things is a substance knowable intuitively, one might even say, in the manner of the "I" in Descartes:

CXXXIX. But it will be objected, that if there is no Idea signified by the Terms Soul, Spirit, and Substance, they are wholly insignificant, or have no meaning in them. I answer, those Words do mean or signify a real Thing, which is neither an

Idea nor like an Idea, but that which perceives Ideas, and Wills, and Reasons about them. What I am my self, that which I denote by the Term I, is the same with what is meant by Soul or Spiritual Substance. If it be said that this is only quarrelling at a Word, and that since the immediate Significations of other Names are by common consent called Ideas, no reason can be assigned, why that which is signified by the Name Spirit or Soul may not partake in the same Appellation, I answer, All the unthinking Objects of the Mind agree, in that they are entirely passive, and their Existence consists only in being perceived: Whereas a Soul or Spirit is an active Being, whose Existence consists not in being perceived, but in perceiving Ideas and Thinking. It is therefore necessary, in order to prevent Equivocation and confounding Natures perfectly disagreeing and unlike, that we distinguish between Spirit and Idea. See Sect. 27.

CXL. In a large Sense indeed, we may be said to have an Idea, or rather a Notion of Spirit, that is, we understand the meaning of the Word, otherwise we could not confirm or deny any thing of it. Moreover, as we conceive the Ideas that are in the Minds of other Spirits by means of our own, which we suppose to be Resemblances of them: So we know other Spirits by means of our own Soul, which in that Sense is the Image or Idea of them, it having a like respect to other Spirits, that Blueness or Heat by me perceived has to those Ideas perceived by another. (Berkeley, 1952, pp. 440-441)

The cause and effect attributes of spirit prove difficult for Berkeley and will be discussed only briefly here. Berkeley wrote during in the age of the enlightenment. Freddoso (1988) identifies him with Marlebranche (1694) and with Biel and al Ghazali from the middle ages as defenders of the position that God is the primary and first cause and only cause of effects in nature. The Aristotelians (among them St Thomas Aquinas, Luis de Molina and Francesco Suarez) while holding that God is the primary and first cause of natural effects (causal relationships) also allowed that each material and corporeal substance possesses and exercises its own proper causal powers. These powers (secondary powers) are not rendered ineffective or disqualified by God, whose primary causation is a general and universal one which concurs with them.

It is in this context that Berkeley's attack on the primary qualities of Newton, Boyle and Lock are to be interpreted. Berkeley's chief goal (after McCraken [1983, p. 211; cited in Freddoso, 1988]) was "to recall Christian philosophy to a recognition of the total and immediate dependence of all things on God" (p. 16). Within this context Berkeley the immaterialist and metaphysician predicated the soul's access to the difficult truths about causation on a commonsense empirical existence of the natural world. Again science (understanding causation) was to be sought through truth.

Soul in the postmodernist era

The emergence of Cartesian dualism precipitated a shift through which "the vegetative functions of the soul were assigned to purely material processes, the sensory functions were attributed to mind and body, and the purely cognitive (and volitional) functions

were assigned to the mind alone" (Hatfield, 1998, p. 6). The *soul* (psyche) of Aristotelian psychology was, during the late 17th century and throughout the 18th and 19th centuries, to be replaced by the *mind* in late modern and postmodern cognitive psychology. Laws of mind were sought, and successive generations investigated old mysteries of being and knowing using old words with nuances of meaning: 'sensation', 'perception', 'conception', 'construction' and the like. By the dawn of the 20th century in the West, God, philosophically speaking, had died (Nietzsche, 1968) and throughout the century Hume's children, as they had long since done, continued to struggle with their legacy until they were engulfed in the moral relativism and constructivism so apparent in the present time. This shift from *soul* to *mind* in cognitive psychology (and its educational psychology applications) is the basis used in this paper to transfer discussion of the *soul* from Berkeley to the postmodern researchers discussed in this section. The common themes which link the three sections of the paper are the ever present mysteries of what it means to be and what it means to know. These postmodern researchers are, in the language and conventions of their day, and like Plato and Berkeley before them, engaging questions of considerable relevance to pedagogy.

Mansfield (2005), in reviewing a book by Braun (2005), catches one aspect of postmodernity well. He speaks of a "just now" (p. 2) characteristic of consciousness – a "systematic production of novelty" (p. 2) which elevates method over substance and which is aided by a modern psychology which replaces soul with self. Knowing the soul within is not the same as knowing the "peculiar disposition of yourself", the latter being more amenable to manipulation by experts and "reformers". Full souled enlightenment, which must carefully extinguish the tutelage of others, must also surmount the ephemeral ego of self. The next group of researchers are writing in the era of the emphasis on self in which metacognition (as charioteer?), and better defined than understood, is central to ideas and concept change and development. These researchers (Flavell, 1976; Hewson, 1982; Hewson & Hewson, 1984; Hewson & Thorley, 1989; Hewson, 1981; Posner *et al.*, 1982) and others cited below write in the book of the constructivists.

Specifically constructivist research argues that individuals (students) actively construct their own understandings of the natural and person-made environments and validate these understandings (a) personally, on an "if it works, use it" basis and (b) socially in various peer group settings. Consequently, classroom environment, teaching style and delivery method, and the prior concept and construct holdings of students, are not the only crucial vectors in the process of education. Peer group, social mores, taboo, ritual, convention, myth, erotic muse, spirituality and religion are also important. Under constructivism prior student construct knowledge holding is central in teaching and learning, but can be diverse and capable of contradicting accepted scientific views. Metacognition and metaconception are considered crucial to the process of active concept change. In particular humans learn how to hold multiple (and sometimes conflicting) "truths" simultaneously.

As mentioned, the writers cited two paragraphs above are amongst researchers investigating the process of skills acquisition through concept change and development, and the efficacy of formal education and training in that process. The literature in this

domain now contains discussions about: (a) operational definitions of conceptual development and conceptual change; (b) the application of such definitions towards the discovery of general guidelines for teaching; and (c) the identification of teacher, learner and classroom environment states compatible with those guidelines.

The literature cited above holds that conceptual change can occur: (a) through extinction of the prior concept; (b) through strengthening or weakening of the existing concept (assimilation or conceptual capture) resulting from its mental articulation; or (c) through exchange of one concept for another. Furthermore conceptual change is explained as a function of: (a) context (called personal conceptual ecology); and (b) necessary conditions for the change itself. Personal conceptual ecology dictates the options for choice and the criteria for choice and there is likely to be wide variation in personal conceptual ecology. Learners benchmark conditions for concept change against their own situation. Essentially conditions are an amalgam of opinions about the intelligibility, plausibility and fruitfulness of the alternative concepts, and benchmarking these opinions about whether or not to accept the concept change appears to be something akin to validation.

Tobin (1996) has identified universal conditions for change (see Table 3) and three important educational referents upon which the conditions partly depend. Components of metaphor are likewise identified.

Table 3: Tobin's universals for change and components of referent and metaphor

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Universal Conditions for Change

- Belief: viable knowledge which individuals employ for goal achievement.
- Action: behaviour predicated upon beliefs and goal aspirations but constrained by *ecology* (context and views about appropriateness). Such behaviour can be observed but linking it to beliefs, goal aspiration and appropriateness dimensions is not clear cut.
- Referent: that which serves as a guide to action and an organiser of beliefs and actions. Referent is thought to be specific to each context.

Three Important Educational Referents

- teacher's personal epistemology
- beliefs about control
- beliefs about restraints

Components of Metaphor

- a verbal part
- an image
- contexts within which the metaphor is thought to be viable

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Source: adapted from Tobin, 1996, pp. 175-189.

Tobin (1996) points out that change is often sought without due regard being paid to the necessary and sufficient antecedent conditions both structural (educational, social,

political, power and economic milieu) and mind (reason-interrogated cognition and imagination). Under constructivism both personal conceptual ecology and conditions cannot be comprised of other than prior construct understandings and it is probably valid to wonder whether or not this understanding may not itself be a progeny of a postmodernist 'rediscovery' or restatement of something like Locke's position on the 'ideas' stemming from 'experience' being defined as sensation and reflection. Metacognition is singled out for its importance in the conceptual choice process of the individual. Unfortunately, when conditions are right ecology may inhibit acceptance of conceptual change as a result of epistemological, cultural or taboo belief holdings.

Implications for teaching follow from the concept change and development findings outlined above: (a) clear definition of conceptual change must inform teaching and curriculum development; (b) conceptual ecology and learner condition constraints need to be considered, in so far as this is possible, in curriculum design and teaching strategy; and (c) personal epistemology, in so far as students recognise it or are willing to expose it, should also be probed. Ideally learners themselves should: (a) want to understand the topic and own the understanding; (b) accept responsibility for their own learning; (c) be able to accept differing views about the subject; and (d) be open in themselves to accept conceptual change.
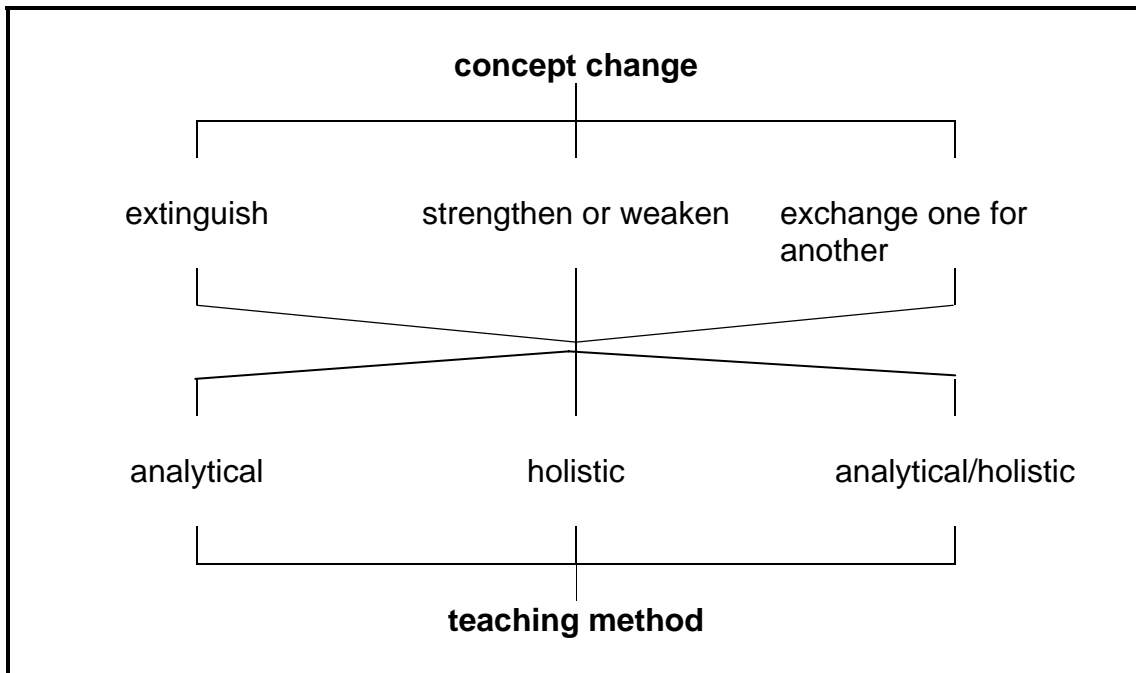
The concept development and change literature has also impacted on teaching praxis. Educationalists and practising teachers (Tobin, Tippins & Hook, 1994; Tobin & Ulerick, 1992), realising that conceptual change involves a reordering of constructs in the status hierarchy of constructs, have identified three general teaching methods. The first, named the analytical approach, focuses on classroom teaching *per se*. It involves the use of educational action and strategy and educational goals, interventions and outcomes defined in terms of commonly understood classroom objects, concepts and constructs. This is the realm of traditional teaching which employs known tools and techniques. The second, the holistic approach, uses metaphor as an image of practice, and through such imagination, and the metaphor switching it permits, both to catalyse change and to provide a channel for that change. The third approach, the metaphor/analytical, is a combination of the first two in which analytical heuristic, although focused on classroom phenomena as outlined above, is nevertheless grounded in metaphor and governed by the liberating imagination it permits. Perhaps (presumably – it is not spelled out), in the analytical approach, reason mainly interrogates cognition; in the holistic approach, reason mainly interrogates the imaginative, fantastic, erotic and emotional depths of the soul; in the metaphor/analytical approach reason attempts to draw understanding from an exploration of linkages and/or transactions that might be found within the cognitive–imaginative intersection.

Of course irrespective of the teaching method being attempted it is possible that proactive and differently gifted students will, of their own volition or habit, be engaged in one of the modes as a matter of learning. Other questions are troublesome, especially differentiating between concept change *per se* and concept development *per se* and whether the two can be separated and/or measured in a meaningful way. Nevertheless general maxims of teaching method relevant to all three approaches have been identified:

(a) the range of prior existing views about a topic should be made explicit; (b) both teacher and student should contribute to the cataloguing of these views; and (c) the views of both students and teachers should, in the first instance, be considered as equals in that they should not attain status on the basis of the status of the utterer.

Figure 1 emerges when categories of teaching and concept change and development are matched. It reveals that nine teaching for concept change and development alternatives are available and that three teaching methods are available once the kind of concept change and development to be taught for has been chosen.

Figure 1: Nine choices in matching teaching method and concept change

concept change

extinguish   strengthen or weaken   exchange one for another

analytical   holistic   analytical/holistic

teaching method

Some specific findings about the concept change alternatives in Figure 1 are available. Grayson (1996) has found that concept substitution is more suited to situations in which the pathway from students' intuitively held conceptions to the preferred conceptions of science is continuous because those intuitive understandings (which unfortunately are expressed in inappropriate terminology) are essentially correct.

Duit (1993) has also been active in developing a teaching method helpful in facilitating the exchange of one concept for another. The method, known as concept substitution, is predicated on the conceptual change research of Confrey and Doerr (1996), and involves using a continuous path process in which students' correct intuitive concepts and constructs are reinforced through teaching and learning experiences during which an intuitive nomenclature is replaced by the preferred scientific nomenclature. This matching of correct prior intuitive understanding with accepted scientific terms helps avoid cognitive conflict which can sometimes hinder learning.

Other researchers (Duit, 1993; Hewson & Thorley, 1989; Jung, 1986; Minstrell, 1984; Scott, Asoko & Driver, 1992) investigating contrastive teaching (a method which embraces the theory of teaching for concept change and the constructivist dictum that prior construct plays a crucial role in the strength of active construction) have found it useful in helping students differentiate between their intuitive views about specific science topics and the preferred views claimed by science.

Finally Hewson (1996) has identified teacher roles perceived to be helpful in teaching for conceptual change: (a) teacher as manager of appropriate classroom climate – context for classroom activity, posing of appropriate questions, unthreatening exploration of underlying ideas, task selection and setting and explanation of behaviour ground rules; and (b) teacher as active participant – balance between leader voice and discovery learning voice, hearing of both student and teacher views, respect for students, wide repertoire of teaching material and resource materials and metacognition about his or her own understandings about the nature of teaching and learning. The desired classroom climate would be one that: (a) respected a multivocality of ideas; (b) provided freedom from fear of ridicule because of the expression of ideas which are contrary or because they seek further clarification; (c) promoted separation of person from idea in that ideas are critiqued yet the person remains affirmed (group work is useful); and (d) predicated lesson preparation on the understanding that the general goal of the lesson is the acceptance of shared (correct) meanings about a topic adopted for their own intrinsic status and not on the basis of teacher 'say so'. Exogenous factors can constrain progress (Ben-Ziv & Hofstein, 1996)

The research cited above under 'soul' in the postmodern era is research in the domain of science and mathematics education. Much of Berkeley's work is relevant to science and mathematics – his refutation of Newton's absolute space and time is well known – and Plato himself turned away from mathematics (towards studying the soul) because of his disenchantment with the occult machinations of the mathematicians he knew. The matches of teaching methodology and concept change alternatives of Figure 1 are unlikely to offend when actioned in the technical domain – for example, switching one concept about magnetism for another. But as soon as they are employed in the domain of the social dimensions of science or in the values and humanities domains they can admit connotations of indoctrination and social manipulation and can even be considered antithetical to the nature of constructivism itself. This is one dilemma for education under postmodernism and moral relativism in the age of the soul as self and the 'just now' ephemerality of values.

Once again the main point of this paper can be made. All of the concept change and development strategies discussed involve having students aspire to the accepted view of science. The accepted view, as the benchmark, must itself be checked through reasoned and careful observation of the phenomena of nature. Lesser forms of validation have little value in science and science education. Nor for that matter should lesser forms of validation be the basis of the search for strong construction in the social sciences. The experience of two millennia, accessed through the writings of even the most metaphysical participants in the great conversation, reveals that mind is wont to seek the highest truths

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by reasoned empirical assessment of the everyday phenomena of nature. This one constant hallmark of science should not be sacrificed to less rigorous or less careful forms of validation.

Conclusion

Empirical observation of the 'facts' remains the hallmark of science and science education. The 'just now' ephemerality of ideas is itself a deception or ignorance associated with the soul as self but is outside the soul. If it were to penetrate the soul, by replacing reason as the stabilising force in the full souled human, thereby becoming something like a lie or defect in the soul (Plato, 1988), the consequences could be serious for both the advancement of learning and the growth and development of society.

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