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AUTHOR	Mashhadi, Azam
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ABSTRACT

As a new century approaches it is time to re-assess the foundations on which instructional design currently rests, as well as the "mode of thinking" that it promotes. Traditional theories regarding instructional design have largely been implicitly based on out-moded eighteenth century conceptions of the physical universe (a mechanistic world view) involving certainty, determinism, and predictability. Using insights provided by 20th century science (particularly quantum theory) into the nature of knowledge, the field of instructional design should cultivate a post-mechanistic conceptual framework which would involve exploring the construction of human knowledge, explicating the use (and limitations) of Aristotelian logic, appreciating the "theory-ladenness" of observation, realizing the role of language in constructing meaning, accepting the role and impact of the observer on what is observed, and appreciating the usefulness of both the reductionist and holistic approaches. Contains 25 references. (Author/AEF)

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Instructional Design for the 21st century: towards a new conceptual framework

Dr Azam MASHHADI

School of Education, National Institute of Education, Nanyang Technological University,

469 Bukit Timah Road, Republic of Singapore 259756

e-mail: <mashhadia@nievax.nie.ac.sg>

Abstract

As a new century approaches it is time to re-assess the foundations on which instructional design currently rests and the 'mode of thinking' that it promotes. Traditional theories regarding instructional design have largely been implicitly based on out-moded eighteenth century conceptions of the physical universe (i.e. a mechanistic world view) involving certainty, determinism, and predictability.

Using insights provided by 20th century science (particularly quantum theory) into the nature of knowledge the field of instructional design should cultivate a post-mechanistic conceptual framework which would involve exploring the construction of human knowledge, explicating the use (and limitations) of Aristotelian logic, appreciating the 'theory-ladenness' of observation, realising the role of language in constructing meaning, accepting the role and impact of the observer on what is observed, and appreciating the usefulness of both the reductionist and holistic approaches.

Introduction

As a new century approaches it is perhaps time to re-assess the foundations on which instructional design currently rests and the 'mode of thinking' that it promotes. Examination of the history of science and the history of education (including instructional design) shows that the two are mutually interlinked, each 'feeds off' the other. In the same spirit 20th century science should provide insights for instructional design as we enter unknown territory, the land of the future.

Fundamental assumptions underlying instructional design

Merrill *et al.* (1996) have argued that the field of instructional design should be built on the rock of science or rather on a particular interpretation of the nature of science as essentially comprising experimental empiricism. In response Jonassen *et al.* (1997) argue that contemporary philosophers of science (e.g. Kuhn, Feyerabend, Rorty) disagree with such a logical positivist picture of science. Furthermore they go on to suggest that traditional conceptions of instructional design are based on assumptions of certainty, determinism, and predictability which are challenged by contemporary science (e.g. quantum physics, chaos theory, fuzzy logic), and that learning is too complex and uncertain to be based on such assumptions (see also De Vaney, 1998; Salomon, 1998; Wilson, 1996; Yeaman, 1994). Traditional models of instructional design assume an interpretation of reality in which:

- Instructional systems are closed systems, which are the sum of their parts…
- Knowledge is an external, quantifiable object that can be transmitted to and acquired by learners…
- Human behaviour and performance are predictable, that is, they are reliable, knowable, and predictable in known circumstances...
- A change in the state of one entity causes a predictable change in the state of another because of a linear relationship between the two (linear causality)…
- Interventions in the learning process deterministically predict the effects of those interventions…

Jonassen *et al.* (1997: 28)

These fundamental presuppositions underlying traditional views of instructional design derive from a 'commonsense' view of the world – which in turn is based on a mechanistic world view, the direct apprehension or knowledge of 'reality', and Aristotelian logic. It will be argued that a mechanistic world view is not inevitable, that there are 'problems' with

Aristotelian logic, and that since perception is 'theory-laden' it is not possible to directly apprehend the world. An argument will, therefore, be presented for replacing the present dominant mechanistic basis of instructional design with one more in keeping with our current understanding of the nature of knowledge (i.e. a new conceptual foundation for instructional design for the 21st century).

The challenge of modern science for instructional design

The quantum theory is currently the most successful theory in the history of science. Quantum physics, however, has raised a number of philosophical questions about the nature of 'reality' and the nature of knowledge. However the understanding of the nature of reality or the conceptual *world view* projected by the current educational curriculum is overwhelmingly Newtonian or 'mechanistic' in character. The *way of thinking* that arise from these new theories must be brought into education as well. Education has traditionally been structured around what is perceived to be the scientist's conception of the natural world.

Newtonian thought is still one of the main pillars on which the curriculum, and the way it is implemented, is based (Doll, 1989). In addition Gough (1989: 227) cautions against educational theories that are based on eighteenth century conceptions of the physical universe, and comments that:

> ... learning in formal settings is geared to the materialistic, deterministic, atomistic, reductionist and objective vision of the universe... Indeed, it would seem that formal education teaches us to distrust our own perceptual systems rather than to exercise the perceptual skills bequeathed to us by natural selection.

At issue is the question of which conceptual framework or 'world view' that education should be promoting. A world view refers to a set of beliefs, concepts and assumptions which may largely be subconscious. These assumptions order and systematise sense perceptions, and help to maintain a degree of predictability in a world of change (Cobern, 1993).

The mechanistic world view

Apart from being the most pervasive world view, the mechanistic world view has come to be regarded as the viewpoint of 'common-sense'; in fact, it is usually presented as the only possible way of apprehending the world (Dijksterhuis, 1986). The modern, mechanistic scientific world view grew out of the success of classical or Newtonian physics which overcame the Aristotelian view which saw the world as an organism. Newton's material causalism, which emphasised material properties, ultimately meant a reductionism in which all natural phenomena is explained in terms of material causality, with the whole is being understood purely by the behaviour of its constituent parts. Apart from the independent individuality of matter, there is also the element of determinism - the future path of a moving object can be completely predicted and its past completely disclosed if its present state is known in all details. Mechanicism is still the 'orthodox' world view and remains a pervasive view in Western culture, including education. The development of quantum theory, however, over the first thirty years of this century has resulted in a new scientific paradigm. What are the implications of quantum theory generally for the nature of knowledge, and specifically what are the implications for education?

The post-mechanistic world view

Systems governed by the laws of quantum theory are not determinate. Quantum theory is genuinely revolutionary in that there is a fundamental change of mind as to how things happen in the world. This is not a matter of adding further facts, but of changing the conceptual framework or world view itself. In less than a century, science has abandoned a world view consisting of concepts that were mechanistic, deterministic and largely absolute, and espoused a world view comprising concepts that are relative, frequently non-deterministic and inherently probabilistic in nature.

It is beyond the scope of this discussion to fully discuss the continuing controversy with regard to the 'meaning' of quantum theory, but a useful (and readable) review can be found in Baggott (1992). The key point is not the 'physics' of quantum physics, but the profound questions that quantum theory raises for a 'post-mechanistic' education. Such a conceptual world view does not assume the necessity of absolute certainty, questions do not necessarily have an answer - let alone a 'right' answer which can be found in a textbook. Learning is, furthermore, a dynamic human activity which involves questioning taken-for-granted assumptions. The question now arises as to whether or not it is (theoretically) possible to develop such a world view or is the mechanistic world view inevitable?

Is the mechanistic world view inevitable?

It has been argued that Newtonian physics forms the basis of the mechanistic world view - a view which is often regarded as being inevitable. Indeed, the philosopher Immanuel Kant argued that individuals perceive a Newtonian world because of innate organising principles that are Newtonian in kind:

> In Kant's system of philosophy, space and time are regarded as synthetic a priori intuitions. This means that instead of being born with a tabula rasa [clean slate], we are born with synthetic a priori intuitions of space and time. These intuitions are hard-wired into the mind in order for us to organize experiences. Kant reasoned as follows: Representations of space and time must be prior to our sensations because we can neither perceive anything nor give an order to our sensations if we remove space and time.
>
> Miller (1996: 190)

The eighteenth-century philosopher George Berkeley argued against such a viewpoint and, in criticising the Newtonian assumptions of an absolute space and time, argued that the representation of objects is the result of our perceptual and cognitive organs. Kant also argued for the necessarily truth of three-dimensional Euclidean geometry. The acceptance of Newtonian space also meant the 'common-sense' adoption of three-dimensional Euclidean geometry as the only possible geometry for investigating nature. The assumption made in school education that this necessarily involves promoting Euclidean geometry and the Cartesian co-ordinate system needs to be considered. The assumption made by Kant that geometry must be Euclidean was undermined in the 1820s with the development of non-Euclidean geometries by Bolyai and Lobachevskii. They both pointed out that no logical contradiction follows from denying Euclid's axiom of parallel lines (i.e. meeting only at infinity). An infinite number of geometries are possible, all of them perfectly rational.

In classical physics an essential feature of the concepts of space and time is characterising the location of an object using continuous Cartesian co-ordinates. However, the physicist and philosopher David Bohm (1970: 208) points out that such a way of thinking is not unavoidable. For example, the location of a pencil in everyday experience is not specified by giving its (Cartesian) latitude and longitude. Instead, the pencil is described as being:

> ... on a certain desk, which is in a certain room, which is in a certain house, on a certain street, etc. In other words, we locate the pencil with the aid of a series of *topological relations*, in which one entity is *within* or *upon* another.

Behind the abstract classical Cartesian co-ordinate description of the concepts of space and time, there is a more fundamental topology, which is, arguably, closer to that used in common experience, and more accurately describes natural phenomena. The assumptions that Euclidean geometry and the Cartesian co-ordinate system must be incorporated into school education is, therefore, not inevitable. Another pillar of the mechanistic world view is the assumption of the uncontroversial nature of Aristotelian logic.

'Problems' with Aristotelian logic

Aristotelian logic has a number of so-called 'laws of thought'. According to the Law of Excluded Middle, a thing must be either A or not-A. The Law of Non-Contradiction states that A cannot be not-A, when not-A represents a category that has been created precisely so that A may be excluded from it. This either/or logic is assumed unconsciously in the world of everyday or 'common-sense' experience. These logical principles are offered as laws of thought, not as laws of thought in the mechanistic world view but laws of thought, period. Doubts about these laws being necessarily true in all situations arise once the meanings of 'is' and 'not' in Aristotle's laws are considered further (Macrone, 1995). For example, consider a statement such as 'a daffodil is either yellow or it is not'. The simplicity of the statement is undermined by disagreement between individuals on how yellow a daffodil has to be to be 'yellow', and even perhaps disagreement on what 'yellow' means. Hence, the application of Aristotelian logic may require consensus on the meaning of the quality or object to which it is applied. In mathematics, problems may arise such as the impossibility of proving that an infinite number is either even or odd.

Some authors have argued that Aristotelian logic is not universally applicable and even that it is culturally relativistic. For instance, Putnam (1969), and Finkelstein (1969) both consider the question of whether traditional two-valued (Aristotelian) logic is a result of environmental conditioning, and argue that it is applicable only to a very large, but still limited range of macroscopic experience. Such viewpoints need to be discussed with great care since it might open up a Pandora's box of undermining rational grounds for choosing between alternatives. The key point here is not that Aristotelian logic should be discarded. Even if it were possible to do so, it is too powerful a cognitive tool to be abandoned. It would not be possible to function in the everyday world that we inhabit without such a form of logic, rather the point is that there should an explicit discussion of the nature of Aristotelian logic, and its use in the construction of rational arguments.

The psychological origin of the individual's intuition about logic lies in the development of the concepts of object, space and number. In the field of educational psychology Piaget and

Inhelder (1951) have observed that the pre-school child's concept of space is topological but that by the age of 12 it is Euclidean. Jean Piaget's researches on the genesis of the concepts of object, space and number, and the psychogenesis of atomism and the conservation laws provide a perspective on why certain seemingly *a priori* categories of thought apply to the macroscopic level of experience. To begin with, the concept of the atom as an invisible permanent object can be apprehended only after the idea of a permanent object in general is formed. However, the features of the classical concept of particle have not survived the conceptual revolution brought about by quantum physics. Specifically, intuitive corpuscular models have been found to fail when used on the microscopic scale. A term has a meaning associated with it within a particular conceptual schema or world view. The same word may continue to be used even though one conceptual schema has ostensibly replaced another (e.g. Newtonian physics replacing Aristotelian physics).

It was earlier noted that underlying the wide-spread 'common-sense' acceptance of the mechanistic world view was the assumption of the direct apprehension of reality. A contrary position has been taken by many philosophers of science (e.g. Hanson, Kuhn). According to this position, data is 'theory laden'; in other words, there is no such thing as 'direct observation'.

The theory-ladenness of perception and another look at 'common- sense'

An inherent feature of common-sense thought is the assumption that its tenets arise directly from experience. However, an integral aspect of what 'common-sense' is comprises the conclusions arrived at by a mind that is filled with presuppositions (Geertz, 1993). Underlying the wide-spread 'common-sense' acceptance of the mechanistic world view is the assumption of the direct apprehension of reality, i.e. observations are not theory laden. However, data can be analysed only within a framework of knowledge or 'conceptual framework' (Kuhn, 1977). In other words, all knowledge is embedded within a historical, cultural, and social framework. In the context of teaching, what the teacher (or software) effectively is doing is initiating students into 'seeing' phenomena and experimental situations in particular ways, i.e. to start to wear the teacher's 'conceptual spectacles'.

The point can also be made that a fundamental aspect of thinking is thinking from a particular point of view. 'Seeing as' is the result of the *interpretation* of perception (Wittgenstein, 1953).

The neurophilosopher Paul Churchland (1979: 7) points out that the current forms of conceptual exploitation or interpretation are largely based on:

> ...the structure and content of our common language, and in the process by which each child acquires the normal use of that language...In large measure we *learn*, from others, to perceive the world as everyone else perceives it.

The common-sense conceptual spectacles through which sensations are conceptually interpreted may be resulting in the systematic misperception of reality. The meanings that words have are partly derived from a slow diffusion into the common culture of the work of research scientists. However, because this diffusion is relatively slow common-sense is built on an out-of-date science. The aim of education should be to speed up the rate of diffusion so that the modes of talking and perceiving incorporate the current scientific insights about the nature of reality. A world view provides a foundation upon which cognitive framework (for interpreting the world) are built during the learning process. The question now arises - how could one move from a mechanistic interpretation of perception to a post-mechanistic interpretation of perception?

The role of language

One of the founders of quantum theory, Niels Bohr, assumed that everyday language, and its formulation in classical physics (particles, fields, position, momentum, energy) is a natural and necessary mode of discourse for people to communicate their experiences. Classical physics, however, developed over millennia, and requires many years of schooling to learn. Language is not static, and depends upon and contributes to a changing social context (Vygotsky, 1989). 'Everyday language or experience' is in a state of flux. The linguist Benjamin Lee Whorf (1950) suggested that through the linguistic systems in our minds we project our grammar onto the world. At the same time, any language has to have some kind of grammatical structure. This structure incorporates tacit assumptions that direct individuals to direct attention to attend to particular aspects of what goes on in and around us and to ignore others. With regard to education, a curriculum which incorporated modes of discourse or thinking which reflected the 'best' understanding of reality that we have at present would lead to the gradual realisation that the mechanistic conceptual framework is not the only possible world view.

Conclusion

In summary the field of instructional design should cultivate a post-mechanistic conceptual framework which would involve exploring the construction of human knowledge, explicating the use (and limitations) of Aristotelian logic, appreciating the 'theory-ladenness' of observation, realising the role of language in constructing meaning, accepting the role and impact of the observer on what is observed, and appreciating the usefulness of both the reductionist and holistic approaches. The development of post-mechanistic theories of instructional design, therefore, involves the development of liberating modes of thinking - true 21st century modes of thought.

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Signature: Azam Mashhadi

Printed Name/Position/Title: DR AZAM MASHHADI (LECTURER)

Organization/Address: SCHOOL OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
469 BUKIT TIMAH ROAD
SINGAPORE 259756

Telephone: 460 5696

FAX:

E-Mail Address: mashhadia@nievax.nie.ac.sg

Date: 3-12-98

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