Decoding devices: the analysis of mental models in a computer classroom

It is arguably as important to consider your students’ qualitative perceptions of the technology they are employing as it is to take quantitative measures of their knowledge or content skills. This paper addresses one of the conceptual aspects of computer education in that it focuses on the mental models students have of computers expressed through both literal and figurative speech. Making sense of this speech has forced the need to develop decoding devices to reveal the models held by individuals and to discern patterns of change in those models over time. This paper will present some of the processes and factors involved in this decoding of data through semantic, semiotic and interpretative devices.

A labyrinth of overt and covert meanings ascribed to computers (and technology) has become embedded within our culture. The aim of a recent study (Lloyd, 1995) was to discern individual ‘meanings’ of computers as expressed through statements (denotation) and metaphors (connotation). These meanings, in human terms, represent an intimate micro-level of understanding which exists independent of the macro-level of cultural myth.

Words, in both conscious and unconscious ways, reveal mental models held by individuals. My study sought to describe change, over time, to the mental models of computers held by adolescent students. This was achieved by seeking responses to verbal prompts at critical junctures in a course of instruction and by taking an operational description of a model to be more of an intellectual and emotional complex in an instant of time rather than an objective image. A mental model is thus a product of subjective elements holding a certain transience; factors which make analysis a difficult task.

Semantic translation of the students’ responses alone could not begin to articulate the complexities of meaning revealed in the words and semiotic analysis alone was inappropriate in this circumstance. It therefore became necessary to develop decoding devices as it were, to reveal the models held by individuals and to discern patterns of change in those models over time. This paper will present some of the processes and factors involved in this decoding of data. Students’ responses are used but their names have been replaced by the letters of the Greek alphabet.

What is a rose?

The following section will paraphrase the aphorism ‘A rose is a rose’ through seven differing arguments to highlight the methods of semantic and semiotic analysis adopted and their classification within a ‘genre of technics’. The first three arguments (1-3) relate to individual and cultural understandings; subsequent arguments (4-5) describe the language and personal characteristics of the sample population which may influence and delimit expression; while the final arguments (6-7) discuss both metaphor and personification.

Argument 1: A rose is a rose

The word ‘rose’ is a semantic denotation of a particular natural object, but is not purely objective. Its enunciation creates an immediate sensory reaction. The word ‘rose’ is also a signifier in a semiotic chain which creates an “associative total” (Hartley, 1985) as images of places and occasions are invoked.

A sign is constituted by the signifier (the material manifestation of the sign) and the signified (the mental concept the signifier may represent or elicit). There can be no signifier distinct from a signified and neither of these can exist outside the construction we call a ‘sign’. All three elements of this composite construct, then, are determined by our culture (Hartley, 1985, p.38)
Two student responses demonstrate this composite construct. They are superficially (and semantically) similar in that they use the same ‘signified’ element i.e. the word ‘box’. But the constructed ‘sign’ in each instance is distinct, indicative of its author’s mental model.

• A computer is a big box with words in it. Alpha, male, 15.25 years.
• A computer is a box that stores memories and that allows you to type so that it comes up on to the screen; it also allows you to go into and search other people’s ideas. Beta, female, 14.25 years.

Signification assumes meaning outside the individual, within social and cultural constructions of language. The first example is simplistic and reveals Alpha’s eidetic child-like image of a computer. The latter example is suggestive of a cultural techno-fear with a certain paranoia evident in the “searching of other people’s ideas”.

This instance shows the need for analysis beyond semantic classification, that is, the occurrence of the word ‘box’ does not denote parity between the statements. Both statements can be further categorised as displaying intentional relationships (Ihde, 1979, 1990; Sofia, 1993) within a defined ‘genre of intentions (Ihde, 1979, 1990: Sofia, 1993)” within a defined ‘genre of technics’, but be seen (again) to be distinctly different.

An intentional correlation places a person as part of the ‘world’ (Fig.1) and secondly as establishing a reflexive relation between the two entities (Fig.2):

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**HUMAN** → **WORLD**

*Figure 1: Intentional Correlation (from Ihde, 1979)*

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**HUMAN** ↔ **WORLD**

*Figure 2: Reflexive Intentional Correlation (from Ihde, 1979)*

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Alpha’s definition of the computer as a ‘big box with words in it’ places him in a position of awareness, but simultaneously excludes him from the process. This exclusion extends to the presumed causality of how the words got to be in the computer, or how he, in turn might get to them. This parallels an initial intentional correlation (Fig.1) in that he exerts little interaction or control within the human:computer interface he has described.

The reflexive stage of this model (Fig.2) embraces the Piagetian notions of action being the origins of knowledge and the framework for abstract reflection being formed through concrete operations. The second ‘box’ response (Beta) reveals this action-reflection as her awareness is extended to personal response and the articulation of a belief statement.

**Argument 2: A rose is a shrub or vine of the genus Rosa**

What something is depends on who is looking - something to do with the ‘eye of the beholder’! No experience is neutral. We view the world through a private weltanschauung constructed from our conception.

Even where students were asked for literal descriptions of computers, a wealth of subjectivity was revealed. Consider the following seemingly objective descriptions:

• A computer is an electrical device which can store information on any subject. It looks like a television and you have a device called a keyboard which is like a typewriter in a way because it is the part you use to write the information on the screen. Gamma, female, 15.08 years.
• A computer is a thing you type on. Delta, female, 16.16 years.

These descriptions immediately position their authors within distinct relationships with the computer. Both reveal a naive experience with word processing which may be the totality of their experience. Gamma has described the computer as a physical object - an artefact - and has revealed an understanding of the concepts of data entry and storage. While neither displays any real enthusiasm for computing, Delta could be seen to be nihilistic in her brevity. These statements could also be categorised as intentional correlations with Gamma showing some measure of reflexivity.

**Argument 3: A rose by any other name would smell as sweet (with apologies to the Bard).**

Whether a rose is a symbol of beauty or a thorny weed depends upon your cultural perspective. What something ‘is’ depends upon what you understand it to be, with all societies implicitly imbuing objects with differing values and worth. One cultural ‘family’ will reverently tend the rose bushes while another may have trouble recognising one.

Turkle (1984) observed a difference between cultural and individual meanings. An individual’s “cultural” familiarity comes through the external use of language and the social conservation of meaning, while their “individual” understandings are constructed internally:

There is a difference between individual familiarity - which allows for and even encourages the elaboration of ideas - and cultural familiarity, which, provides ready-made answers.

(Turkle, 1984, p.33)

It is difficult to ascertain what the cultural ‘meanings’ of the computer are in contemporary society. It could however be deemed to be a positive image; one with a chameleon like potential to be many things to many people. The enduring cultural myth - fostered by science fiction - is that a computer is intelligent, its prime business being thinking, calculating and storing data. This presumed cultural stereotype of a computer, Turkle’s “ready-made answer”, was seen in the following response (made before any computer instruction was given):

• A computer is like a human brain. Epsilon, male, 14.91 years.

A further stereotype was evident in the following (pre-tuition) responses, which are marked by their extraordinary optimism and their subliminal links to mythology:

• A computer is like a box of miracles. Zeta, male, 14.5 years.
• A computer is like an undiscovered country waiting to be discovered and used to its full potential. Eta, female, 15.33 years.

These metaphors are revelatory of cultural meaning, the contemporary cultural myth of the computer as an artefact of great power. The mythic
references in the statements are associative links to Pandora’s box and epic journeys into the unknown. Dowling (1991) spoke of metaphorical language as being “deeply rooted in and supporting the social context in which the individual and the language operates” (p. 50).

That these ‘mythic’ responses were made prior to instruction is significant. All subjects cited here replaced the ‘cultural’ with ‘individual’ meanings at the close of the course of study. There remains a vestige of ‘register’ in their responses in that they may have been attempting to please the teacher and provide what they believed would match my beliefs.

Argument 4: A rose in Spain stays mainly on the plain

To hear the meaning in words, you must not listen with your ears - the ear of the beholder? You must be alert to your subject’s language, the parole of their daily life.

The idea that there is a single ‘normal’ language, a common currency shared equally by all members of a society is an illusion. Any actual language consists of a highly complex range of discourses, differentiated according to class, religion, gender, status … which cannot … be neatly unified into a single homogenous linguistic community. (Eagleton, 1986, p. 5)

Different situations demand that a paradigm of words be formalised into specific uses for specific situations. These are referred to as ‘registers’ in both semiotics and linguistics. The paradigm imposed by the classroom and the register of appropriate language used by students to respond to their teacher will modify and codify the data.

Alternately, certain words and phrases have ‘use-by’ dates. The vernacular of a society changes quickly. Consider the reaction to the following if they were being read in 2096:

- A computer is like Zeta’s head - CRAP!
- Lambda, male 14.41 years.

The following statement ends with the term “NT”. This is an abbreviation of the word ‘NOT’ which adolescents of the mid-1990s have adopted as a witty rider to negate any conciliatory statement they have made. It has to be said in either a melodic or emphatic way after a short pause.

- Programming is like watching a game of AFL football at the MCG with 100,000 people surrounding you, cheering and having fun. N’T.
- Mu, male 14.83 years.

These statements, despite their future incomprehensibility, offer an interesting glimpse into adolescent behaviours of rebellion. Some, like Kappa felt that a confrontational stance was important to cover his own learning difficulties; others used subtler, more ironic forms of resistance. The ‘totally tubular’ comment was sarcastic with Iota offering a diametrically opposite view to his own. He found programming a terrible chore, but here wryly offers a superlative. It is interesting that ‘totally tubular’ was not in his usual parole - when he really thought something was fantastic, he would say it was ‘filthy’. How would future readers handle that one! Lambda was displaying stereotypical banter with his best friend, Zeta - with whom he shared the written comment and was rewarded with a hearty grin. But Mu is my favourite! Humour is a wonderful form of resistance and here we are resoundingly duped! He builds an effective image; gives us a sense of the movement, warmth and sound of the crowd and then … we are cruelly brought back to reality.

Argument 5: A rose is MY rose

It has already been suggested in this paper that what something is depends on who is looking! That ‘whoo’ brings individual characteristics to bear upon the experience. Hormones of the beholder?

Turkle (1984, p. 18) offered a developmental schema of human: computer interaction which maps experience to age and maturity. The first stage is the metaphysical where young children encounter computers and are not completely certain whether they “think, feel, or are alive”. The second is identified as a stage of mastery where there is less speculation about the computer but more of a concern with competence and success. The final stage noted by Turkle is one of identity where adolescents use the computer as a point of reflection of their own self-definition and self-creation.

The population of my study was adolescent and their interaction with computers was, as Turkle (1984) suggested, focussed on ‘self’. The human:computer interface was egocentric with attitudes being expressed as personal reactions.

Ego-centrism (e.g. it’s too hard for me, something I don’t enjoy) and emotion were evident. Personal reactions were offered in the closure tasks even when there was no linguistic cue to do so i.e. no personal pronouns were used in the prompting statement.

Response to: Computers are not …
- Computers are (with a care interjecting the qualifying word ‘definitely’) not something I am interested in.
- Nu, female 14.33 years.

Response to: A computer is like …
- A computer is like my brother (annoying).
- Xi, female 14.66 years.

- A computer is like my little sister; it doesn’t do anything unless you make it.
- Omicron, female 14.00 years.

- A computer is like my science teacher, dull, boring and something you wouldn’t even want to communicate with.
- Pi, female 14.33 years.

Response to: Programming is like …
- Programming is like trying to talk to your mum.
- Rho, female 14.5 years.

- Programming is like some kind of mental problem that makes you go crazy.
- Sigma, female 14.16 years.

- Programming is like eating pumpkin - I don’t care if I have to or not.
- Tau, female 14.5 years.

- Programming is like nothing - it made no sense to me.
- Upsilon, female 15.16 years.

The responses of these adolescents (mostly naive computer users) were resonant of personal attitudes, values and
experiences. They were usually emotive, often pejorative, focused on the self. The subliminal message was one of powerlessness and frustration.

The inherent negativity of the egocentric statements forces the categorisation of these statements as being exemplars of a hermeneutic correlation. Ihde (1979) identified two kinds of hermeneutic relations. The first is where the machine, either through technical difficulty or complexity of use, requires conscious focus thus preventing embodiment relations being formed. A hermeneutic relation is apparent in the occurrence of the typographic error whose jarring effect Stern (1991, p.68) described as revealing "the presence of the vehicle in the pure transmission of meaning". The experience is with the machine as a machine (Fig.3), objectified and thematised, not as a transparent component or conduit of ideas.

HUMAN                MACHINE-WORLD

Figure 3: Hermeneutic Relations (from Ihde, 1979)

Sofia (1993) described the hermeneutic relation through the phrase 'technology as sign' meaning that the interaction with the machine is through dials, gauges or switches; the outward signs of action. Sofia (1993, p.94) equated this relation to the metaphorical form, synecdoche (inferring the whole from one part). The 'whole' inferred from eating pumpkin (a disliked food) is easily engaged as an adolescent voice coming to terms with limits and controls; it is a voice which most adults can hear with extraordinary recall and clarity. The vehicles offered in the students' metaphors are semiotic 'signs' and here all share a commonality of disempowerment.

Argument 6: A rose is anything but a rose

My study specifically sought metaphorical responses from its subjects where the computer was described in terms which removed it from its form or functions. The main types of metaphor are personification, allusion, irony, overstatement, understatement, synecdoche and metonymy.

A metaphor is literally absurd and its denotation is clearly untrue. It offers a stimulation of thought through the placement of "salient dissimilarities - in the context of salient similarities" (Carroll, Mack & Kellogg, 1992, p.74). The meaning of any metaphor is interpretative with the words being merely connotative of that meaning. The 'truth' lies in the illusory 'ground' between the tenor (the primary subject) and the vehicle (the secondary subject). The meaning of the metaphor is significantly different from and greater than the semantic meaning or denotation of its component parts.

A metaphor thus becomes an interactive and implicative complex between the tenor (primary subject) and vehicle (secondary subject). Black (1979) stated that "every implication-complex supported by a metaphor's secondary subject ... is a model of the ascriptions imputed to the primary subject" (p.31). Metaphors expressed by the subjects were thus taken to be an indicator of the mental model held by that subject, as in the following examples:

- A computer is like an overcast sky before a hail storm. Dark, gloomy with bits of green colour on it.
- A computer is like a TV show that is never the same as you can change the outcome yourself. It is appealing because everyone wants to make up their ending to a show.

These metaphors are thematically linked to control. Phi wrote evocatively of the threatening sky and was surprised by her own words. She was a straight 'A' student who had not really succeeded in learning how to program, placing her in an unfamiliar position of vulnerability. She was frightened by her lack of control of the learning task. The semiotic 'sign' is the threat. Her metaphor places her within a reflexive intentional correlation.

Argument 7: A rose? Sweet Rosie O'Grady!

An intriguing theme throughout the study was the persistent personification of the computer. Comments would be made in class which accorded human characteristics to the machine (It won't listen to me; It hates me). The final metaphors (post tuition) were marked by increased personification with the process of control.

Similarly the boy, Psi, who described the TV show with the viewer in charge of the sequence and outcome of a story is also describing control. There are tangible links here with game playing and the non-linear navigation offered by multimedia programs. His statements are more indicative of an embodiment relation where he, the user, becomes an integral part of the action of the machine.

Embodiment relations can be described through metonymy (Sofia, 1993). Metonymy reduces a process to its symbols, thus "a part (of the body or the sensory spectrum) is selectively invested at the expense of the whole" (Sofia, 1993, p.93). Psi had reduced the whole gamut of computer operations to one TV program or its equivalent as a computer game.

The embodiment of a computer must evolve from its transparency. It follows that if a subject is a confident computer user and the machine is performing without fault, then the relation can become one of embodiment. The subject, through (and with) the machine, composes or calculates, creates or collates with a focus on the outcome rather than the medium. Psi controlled the outcome of the narrative.
computer being likened to human beings - most usually infant, dysfunctional or disabled - in need of care or instruction.

- A computer is like a child you’re talking what to do.
  Omega, female, 14.9 years.
- A computer is like an awkward person.
  Zeta, male, 14.5 years.

This relationship is described through the second of the hermeneutic relations (Ihde, 1979, p.12) “the machine becomes ‘other’”. Sofia (1993, p.97) described this as an ‘alterity relation’ with ‘metaphor’ being its dominant linguistic form. Alterity relations are formed where the personification or anthropomorphisation of the machine permits a ‘conversation’. The anthropomorphization of the machines creates ambiguous relations:

This is not to say in any case that the machine has intentionality - but it is to point to the source of such pseudo-problems in the structure of the relationship itself. In relations in which machines are focal “other”, all of the ambiguity of other relations becomes a possibility.

(Sofia, 1993, p.92)

The alterity relation as ‘technology as second self’, a term derived from the work of Turkle (1984). The underlying concept is that the machine becomes the user’s alter ego being attributed the user's intentions, hopes and fears. The machine is accorded a psychology, but it is that of the user. Zeta’s “awkward person” is in fact himself; he has travelled far from his ‘box of miracles’. The verbal outpourings to the machine are aimed at that elusive nameless part of the psyche who looks after the automatic tasks for you.

**Conclusion**

'The question is', said Alice, ‘whether you can make words mean so many different things”.

(Alice to Humpty Dumpty in Through the Looking Glass)

It would have been a simpler task to merely count words or to react to the literal interpretations of what had been said. ‘Making the words mean so many different things’ involved both semantics and semiotics. Ihde’s ‘genres of technics’ was the chief reference, providing a constant matrix of behaviours from which to plot and record any changes within the sample population.

The outcome of the study was that it allowed me to ‘see’ the computer through my students’ eyes - and most alarmingly, to realise that what we were all seeing were very different things. It also allowed me to plot changes in my students through a course of study. Changes which irrevocably dented the initial cultural myths they had held about what computers are and what they can do! Ultimately the most cynical of the students seem to be the most effective computer users - they were the ones who dismissed the hype and took control. The ones who accorded the computer the strongest personality were generally the ones who exercised the least control over the machine. The ones, like Zeta, who began so optimistically had the furthest to fall.

What I have offered here is an overview of the factors involved in extracting meaning from words. It is necessarily complex because all words are subjective and cannot be presumed to mean what they say. It makes me wonder if you are reading what I am writing? Or if I am writing what I am thinking?

I hope the answer is ‘yes’. A to Z are just letters; but here, Alpha to Omega are human beings with thoughts and fears. ‘Computer’ is just a word. A rose is a rose, or is it?

**REFERENCES**


