SEARCHING for control in a post-modern mathematics classroom.

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Educational authorities are advocating for schooling to be a positive experience for all students if they are to continue to participate as life long learners throughout their lives. In many ways, mathematics education is failing to achieve this. Education systems around the world are exploring ways to manage pathways for students to better enter the "Learning Age" and the "Knowledge Society" with high levels of skill and confidence. In a time of post-modern paradigmatic perspectives, mathematics classroom teachers are developing pedagogies whereby students become more self-directed and motivated as learners. One method called SEARCH has responded to post-modern changes by providing the opportunity to reconstitute the locus of power in the classroom. Instead of the seat of power residing within the teacher, SEARCH transfers the locus of power to the students. This paper will discuss how the post-modern paradigm can assist mathematics classroom teachers in reconceptualising their teaching approach. Ways that empower children to take more control of their learning of mathematics will be demonstrated.

Post-modern influences

The "Knowledge Society" in a post-modern world is characterised by a relentless process of change. Paradoxically, "change generates fear, anxiety, panic and uneasiness on the one hand and exhilarates, excites, develops opportunities on the other (Fanthome, 2004, p. 17). While almost universally mathematics is acknowledged as a subject that correlates strongly with human fear (qua anxiety and feelings of vulnerability), working with mathematics also produces powerful feelings of awe, stimulation and excitement. A question often asked when considering the apparent contradictions between mathematical empowerment and mathematical debilitation is: Is it the mathematics that is failing to excite students or the way mathematics is taught? To a large extent mathematics is not seen as the root of the problem, or the perpetrator of ill feelings but rather it is the teachers – but not the teachers as people per se but rather the methodologies they employ and the approaches they take in delivering experiences that are mathematically challenging to new students.

Referring once again to the "Knowledge Society" it is noticeable that many educational programs are presently being developed and delivered by curriculum designers who don't actually understand what the knowledge society is. In contrast to 21st century thinking, mathematics educational programs continue using teaching methods no more appropriate for today's society than a model-T Ford is for the grand prix (Passmore, 2005). Agreement is rapidly mounting that across the globe, there is a need to reconceptualise mathematics curriculum thinking. Many argue that the demands of the knowledge society and knowledge economy require new approaches to learning. Learning can no longer be limited to formal schooling based on attitudes and approaches that do not resonate with the post-modern world.

New scientific perspectives including quantum physics are changing the way the world is explained (Bertalanffy, 1968; Capra, 1996; Luhmann, 1995). Embodied in new scientific thinking is the recognition of the fundamental interconnectedness of human beings. In the education sphere, these new scientific principles are helping to portray the student as an integrated, active and competently engaged participant rather than a deficient or developing junior version of an adult awaiting the wisdom of superiors (Edwards & Knight, 2000). The hegemony of the deficiency model has had a restraining and detrimental effect on the learning of mathematics. A clinical preoccupation with cognitive development driven primarily by Piagetian stage-based perspectives during the latter half of the 20th century, has been by and large at the expense of the systemic and integrated aspects of physical, emotional and social development that impact upon student learning. The logic of "relationship" as derived from perspectives of complexity theory and systems theory emphasizes notions of change as a process that is holistic rather than piecemeal. Patterns of "organization and emergence" (Fleener, 2002) are central to the synergistic organizational dynamics of an evolving system,

such as a classroom or a growing, learning individual. The whole is greater than the sum of its parts.

The proactivity of recognising the classroom as a dynamic and evolving system based upon "relationships" (cf. McClain and Cobb, 2001) can be extended metaphorically as a "SEARCH" – that is to say, the learning process involves the learner searching to make meaning and the teacher searching to understand the learner's meaning-making. Learning and teaching become a reflexive phenomenon based in "interconnectedness" where teacher and student search together as co-constructors to make sense out of the meaning-making experience. Learning is a SEARCH for meaning on two levels – the teacher's search for how the student is progressing; and the student's search to make meaning.

Systemic relationships

As an area of new science, quantum physics is showing that the ideal of "*scientific objectivity*," no longer holds (Wheatley, 1994). Instead of a world of certainty and predictability, quantum physics portrays reality as a systemic interconnectedness that undergoes change as a result of interacting with itself, its environment or other systems, where nothing is independent of "relationships" and everything is in a constant flux of dynamic inter-subjectivity (Lerman, 1996; Maturana & Varela, 1980). In post-modern terms, our world exists as "relationships," as a world of process, not things. The world of "relationships" is in a spontaneous state of becoming and self-organization. These are the basic principles of a future of unpredictability where everything in the world will be open and susceptible to processes of change. Reality is itself in process and the ultimate principle will be a "relationship" with experience; but not experience removed or separated from ourselves as Plato or Descartes would have us believe but rather, experience as the reality of our being (Whitehead, 1978, cited in Doll 1993). The idea of systemic "relationship" has become the hallmark of economic, political, social and scientific progress. In order to keep abreast with emerging scientific thinking, educators are being called upon to be responsive with new conceptions of knowledge, teaching and learning. However, the implications of promoting a systems-theory perspective of relationships as fundamental to learning are enormous.

If we view the classroom as an unfolding, evolving and open system determining its own dynamics and direction, and through dynamic interconnectedness determining its own meaning, then everything is free to adapt and open to change; the "relationship" between teaching and learning takes on a completely different perspective (Geoghegan, 2002).

Let the SEARCH begin

The bi-perspective aspect of the "SEARCH" heuristic provides a simple framework for teachers to make a shift towards 21st century post-modern teaching. In order to reconceptualise the teaching of mathematics, the SEARCH heuristic elaborates the basic principle of post-modern thinking, namely relationship; it reconstitutes a new relationship between teacher and student and teaching and learning. The locus of classroom control is located closer to the learner and further from the teacher. Although SEARCH involves what can be described technically as three psycho-pedagogical reflexive complementarities, SEARCH simply stands for Social Emancipation (SE), Active Referencing (AR), and Creative Heuristics (CH). These three simple ideas form the basis of good mathematics teaching and a new relationship in the learning context.

Research has shown that the development of systems-based classroom involves negotiation of socio-cultural norms as an ongoing process and, the students' participation in the negotiation as crucial (McClain & Cobb, 2001). SEARCH implies that learning is not a destination, nor a journey but a never-ending search; knowledge is not extracted from an objective reality but rather, is constructed by making connections with life's experiences. The classrooms that employ the SEARCH heuristic do not propagate behaviourist learning theories. Instead, the classrooms resonate with a new generation of scientists and teachers who seek to explain

learning and knowledge, as "… a shift from quantity to quality… characteristic of systems thinking" (Capra, 1996, p. 135).

The SE in SEARCH (Social Emancipation)
In a SEARCH classroom, a problem-centered approach to learning imbued by constructivist perspectives is fundamental. As students learn mathematics in a self-regulating and self-organising classroom, notions of partnership, cooperation, agency, individuality, freedom and democracy develop. These perspectives interweave in "relationship" with each other. The learning environment generates and celebrates diversity in cognitive, social, emotional and physical development based in respect for each other and for each person's attempt to make meaning…including the teacher's. In the SEARCH classroom, learning is based on respect. Therefore, (1) competition is replaced with cooperation; (2) collaborative efforts to develop solutions are applied to both social as well as academic problems; (3) each student's attempt to express a mathematical proposition is venerated; (4) coercive authority from the teacher is rejected; and (5) personal agency is promoted. In the SEARCH classroom, what it means to "know" and to "do" something is thus what it means to "learn" with a big L. The five dimensions listed above exemplify the process of social liberation, mutual respect and democratic freedom….or in other words, social liberation. Emancipation of the individual leads the teaching approach.

Such depiction of the classroom reflects the writings of John Dewey – "students and teachers alike – [are] invited to find personal fulfilment and social well-being in their daily activity, [the classroom becomes] a place where the ultimate test of knowledge [is] its usefulness …where the useful [includes] the aesthetic, the contemplative and what some would call the spiritual aspects of human experience" (Jackson, 1990, p. xxxvi).

The AR in SEARCH (Active Referencing)
In the SEARCH classroom, student's thinking revolves around efforts to let them negotiate meaning for themselves, with and amongst themselves, to build upon their previous knowledge, and to be viewed individually as unique learners with unique and interesting ideas. There is a distinct effort by the teacher not to tell children the answer. The aim is to provide a learning environment in which children are unencumbered (by pre-conceived and pre-determined thinking) in their search to construct meaning. The learning environment is strongly activity-based, hands-on, participative, engaging, motivating and interactive. There is an expectation that each lesson is an active use of time, space and shared thinking. Not only is cognitive growth addressed, but also social, emotional, and physical growth. The teacher's role is not to "teach" children but to facilitate experiences that provide active engagement in the construction of ideas. Learning based upon active engagement develops around working "relationships" of partnership and friendship, not just in an inter-active but also an intra-active way. Children are expected to utilize all their senses and capacities inter- and intra-actively, in "relationship," in a holistic fashion to think and to share their ideas with others.

In light of constructivist perspectives that portray new knowledge as concepts based on previously constructed personal ideas, the SEARCH classroom rejects structuring lessons around transmission principles – i.e. where the teacher tells the students everything. Instead of transmitting instrumental and procedurally rule-oriented examples, the teacher encourages inter-dependent sharing of possible ways to explain an idea. The construction of knowledge harmonizes in a reflexive "relationship" between group interaction and individual sense making. This reflexive view of learning implies that knowledge is not constructed purely in isolation as a personal experience. Rather, learning is also inter-personal. Teaching then encourages students' active participation and engagement through self-direction. Instead of being traumatised by blind faith and merely following the teacher's imposed directives, students learn to actively reference their own and other's ideas in order to make sense of the mathematics they encounter.

The CH in SEARCH (Creative Heuristics)

Eisner (1994) suggests that teachers need to "provide a climate that welcomes exploration and risk taking and cultivates the disposition to play. To be able to play with ideas is to feel free to throw them into new combinations, to experiment, and even to "fail" (p. 162). For it is through play that children eventually discover the limits of their ideas, test their own competencies, and formulate meaning - what works and what doesn't….what makes sense and what doesn't. The SEARCH classroom is dedicated to inventing new ways and devising uniquely creative ways for discussing, validating, expressing, and describing mathematical conceptualizations. As Elkind (1998) remarks, the child is most happy to share his or her thoughts if teachers show interest in their ideas. Teachers get insight into the child's thinking. If teachers communicate that they are interested, not in terms of right or wrong, but in a genuine attempt to comprehend what the child is proposing, they are able to promote the child's sense of self-confidence and security in expressing often unique and personally liberating ideas.

In the SEARCH classroom, children's personal sense making revolves around an environment that is conducive to spontaneous and creative discussion. Establishing such an environment engenders a high degree of patience and tolerance. Children's willingness to speak openly is paramount in the success of the learning process. In order to foster children's capacity to express unique ideas, teachers allow children a measure of freedom to roam the room with autonomous flexibility and interact with their peers in informal ways. The children's freedom is based upon a socio-cultural norm, as long as they respect each other's attempts to complete the projects assigned, they are free to sit, cluster, or gather wherever they wish to work. "Empathy, playfulness, surprise, ingenuity, curiosity, and individuality must count for something in schools that aim to contribute to a social democracy" (Eisner, 1994, p. 367).

The SEARCH continues

Such a fluid and inventive learning environment might be considered prone to disruption and even chaotic behavior. The important issue here is that the SEARCH model of classroom engagement fosters systemic self-regulation not just during the mathematics lesson but for the entire school day. As Jantsch (1980) suggested, as a system changes, it does so by referring to itself. Self-reference is what facilitates orderly change in turbulent environments. "The natural dynamics of simple dissipative structures teach the optimistic principle of which we tend to despair in the human world: the more freedom in self-organization, the more order" (p.40). In other words, the control of the class endures in systemic order because the "relationship" between learning, freedom and autonomy is self-regulating. In accordance with emerging views of New Science, the driving force for learning is to be found not in controlled or imposed structures, but in life's inherent tendency to "create novelty, in the spontaneous emergence of increasing complexity and order" (Capra, 1996, p. 228).

Whitehead (1978, cited in Doll 1993) believed that the "ultimate principle" of reality itself was a relationship of becoming and perishing – a relationship of experience. He argued, in contrast with a Newtonian view of an ultimately atomistic and mechanical reality, that reality was a set of relations. In consonance with Dewey and Piaget, Whitehead thought that the pupil's mind was "a growing organism" and that "the only avenue towards wisdom is by freedom in the presence of knowledge" (p.30). According to Whitehead, "ideas give power to create, to bring into actual existence an infinitude of possibilities. . . . For this reason it is not only good that we, as teacher and students, throw 'ideas into every combination possible'; it is essential we do so. For in this 'throwness,' meaning, experience, and reality are created" (Doll, 1993, p. 145).

Organizations and business systems outside the education sector are increasingly paying heed to the properties of self-organization and self-renewal. Some theorists have termed these "adaptive organizations" and "learning organisations" where the task or problem to be solved determines the organizational form (Dumaine, 1991). As Holloway (2004) points out, the key to effective and healthy organisational models in the 21st century is "open debate and discussion" (p. 27). Today's learning organizations are depicted as avoiding rigidity or permanent structures and instead developing a capacity to respond with greater flexibility to external and internal change. Teams, action, knowledge, expectations, and norms emerge in

response to the organisation's needs. When a need changes, so does the organizational structure. It is acknowledged that a self-regulating systemic classroom requires a high degree of patience and a considerable tolerance for chaos. Establishing "relationships" and operating close to the border of chaos requires considerable managerial fluidity - rather than managerial rigidity. Teaching this way requires adaptability to operate with constantly emerging divergent ideas – to allow ideas to "spiral off into the unknown, as in the beautiful iterations of complex numbers found on the edge of the Mandelbrot sets" (Doll, 1993, p. 126).

As John Dewey says:

One can think reflectively only when one is willing to endure suspense and to undergo the trouble of searching (cited in Pollard, 2002, p. 4).

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