

Learning Mathematics: a SEARCH for meaning.

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Abstract In early childhood education (children aged birth to eight years), educators have an enormous responsibility in developing children's disposition towards mathematics especially in light of the fact that many children have decided by age eight whether or not they will ever be "good at doing mathematics." Following Freudenthal's suggestion that humans should learn mathematics as an open rather than closed system, this paper describes a psycho-pedagogical heuristic for early childhood mathematics education called "SEARCH." Developed from a post-modern perspective emphasising *relationship* as central to developing young children's mathematical thinking, the heuristic is metaphorically portrayed as a "SEARCH" – i.e. each of us (learner and teacher) navigate knowledge while searching for meaning; the learner searches to make meaning and the teacher searches to understand the learner's meaning making. Teaching and learning become a reflexive phenomenon based in *relationship*. The paper will discuss notions of ecological and systemic *relationship* in a mathematics classroom established using the SEARCH acronym: SE = Social Emancipation, AR = Active Referencing, and CH = Creative Heuristics.

Modern and post-modern views

The works of Dewey, Mead, Vygotsky, Piaget and Whitehead resonate with the idea that learning is a "SEARCH" for meaning; not a search to reveal or discover an objective or absolute reality but a construction of meaning that builds from within each of us through a process of self organisation and reflective analysis as we make sense of our experiences. Mathematics educators continue to challenge learning that is based upon modernist/positivist assumptions of objectivity, absolutism, linearity and predictability.

Although the modernist/positivist perspective lives on as a significant (if not "the") force of mathematics curriculum practices around the world, it is increasingly being considered to have outlived its usefulness in most 21st-century early childhood education contexts. In more recent post-modern times, early childhood mathematics education is resonating with a more systemic *relationship* constituted by the perspectives of "constructivism" (Cobb & Bauersfeld, 1995), "problem-centered learning" (Murray, Olivier & Human, 1998), "systems theory" (Capra, 1996), and "positive discipline" (Kohn, 1996; Nelsen, 1996). Such a systemic *relationship* is yielding an interconnected, evolutionary and reflexive dimension to mathematics education.

Systemic relationships

Because of what has been shown to happen in the quantum world, the ideal of scientific objectivity no longer holds. Nothing in the quantum world happens without something encountering something else. Nothing is independent of relationships and everything is in a constant flux of dynamic processes. This is a world of process, not of things. Complex systems are in a spontaneous state of becoming and self-organizing. The future is unpredictable. It is a world where everything is open and susceptible to change. As a result of discoveries in the quantum world, "*relationship*" has become the hallmark of New Science while at the same time providing new conceptions of knowledge, teaching and learning. Wheatley (1994) suggests that "*we are beginning to recognize [classrooms] as systems, construing them as "learning organizations" and crediting them with some type of self-renewing [coherent, evolving and interactive] capacity (p. 13) . . . we talk of quantum interconnectedness, of a deep order that we are only beginning to sense . . . a constant weaving of relationships, of energies that merge and change, of constant ripples that occur in a seamless fabric [of learning]."* (p. 20)

Understanding *relationship* as the key determinant of social, political, economical and scientific knowledge is the exigent preoccupation of New Science. In mathematics education a similar imperative is emerging as foundational to the idea of the post-modern classroom (Doll, 1993). Indeed, with the new emphasis on systemic *relationships*, a new sense of educational order is emerging between teachers and students, and teaching and learning, which will culminate in a new concept of curriculum. The traditional modernist systems that dominate mathematics education today are giving way to more complex, multi-faceted self-organising systems.

Working with a whole-system approach to mathematics education requires a very different set of expectations and analytic processes. Rather than creating a model that forecasts the future of a system, nonlinear models encourage the modeler to play with them and observe what happens. Different variables are tried out in order to learn about the system's critical points and its homeostasis. 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 mathematics takes on a completely different perspective. A classroom characterized by open, dynamic, creative, and adaptive processes alludes to a very different approach to mathematics education than is to be found in traditional linearly oriented settings. "This is such a remarkably different approach to analysis, this sensing into the movement and shape of a system, this desire to be in harmony with it. The more we develop a sensitivity to systems, the more we redefine our role in managing the system. The intent is not to find the one variable or set of variables that will allow us to assert control. This has always been an illusion anyway. Rather, the intent becomes one of understanding movement based on a deep respect for the web of activity and relationships that comprise the system" (Wheatley, 1994, pp. 110-111)

Through the idea of *relationships* mathematics education embraces post-modern perspectives of interconnectedness and interdependence. In order to implement the current mathematics reform agendas (c.f. NCTM, 2000) perspectives reflecting a new awareness and sensitivity to the *relationships* between learning and teaching need to be articulated. Traditional approaches are no longer adequate. The heuristic "SEARCH" provides a basis for teachers to make a paradigm shift that emphasises *relationship* as a central tenet of the learning experience.

The SEARCH heuristic has been formulated upon the reflexive complementarities of three psycho-pedagogical dimensions, namely, Social Emancipation (SE), Active Referencing (AR), and Creative Heuristics (CH). SEARCH is given form by the metaphor "learning is not a destination but an ongoing search," knowledge is not derived as part of an objective reality, but rather as a personal and intersubjectively connected sense of knowing. The metaphor is made more relevant and multi-dimensional by relating it not only to children's search to make meaning in their mathematical endeavours but also through the teacher's search to make sense of each child's cognitive, social, emotional, and physical needs in order to make developmentally appropriate decisions about what next to include in the curriculum.

As such, the search for mathematical meaning is portrayed as a complex reflexive *relationship* founded upon sociocultural and sociomathematical norms (McClain & Cobb, 2001). The SEARCH heuristic finds agency within the new generation of mathematicians and scientists who seek to explain learning and knowledge, and "represents a shift from quantity to quality... characteristic of systems thinking" (Capra, 1996, p. 135). Research has shown that negotiation of sociocultural and sociomathematical norms is an ongoing process and that students' participation in the negotiation process crucial. The execution of each mathematical experience is contingent upon children's emerging appreciation of their teacher's and their own roles during mathematics lessons. As classroom norms are negotiated new relationships are established as the class co-evolves into new roles with new expectations. As the roles evolve, new norms emerge and so the cyclical and reflexively emergent nature of learning manifests as a process of continuous self-regulation and self-organization.

The SE in SEARCH The SEARCH classroom involves a problem-centered approach to learning imbued by constructivist and positive-discipline perspectives. The learning experiences are characterised by notions of freedom, democracy, child-centeredness, active engagement, developmentally appropriate problems, and the opportunity to think creatively. The interconnected *relationship* among all these perspectives interweaves them together.

Children's analysis and discussion of mathematics that takes place in the classroom reflects what it means to "know" and to "do" mathematics and thus what it means to learn mathematics. Sustaining a psycho-pedagogical dimension of mathematical development as an inter-relational perspective of democratic partnership is based on (1) replacing competition with cooperation, (2) fostering collaborative cooperation for reaching solutions to social as well as academic problems, (3) respecting each individual's attempt to have an opinion, (4) rejecting coercive authority, and (5) promoting personal agency.

Deriving from principles and *relationships*, mathematical learning based on respect (by teacher and students) for student intellectual, social, physical, and emotional development is akin to the self-regulating and self-creative basis of complex adaptive systems. Such an elaboration of the classroom environment resonates with what is portrayed in the writings of Dewey in that the classroom is a place "where the inhabitants - students and teachers alike - [are] invited to find personal fulfilment and social well-being in their daily activity, a place where the ultimate test of knowledge [is] to be its usefulness but where the useful [is] to include the aesthetic, the contemplative and what some would call the spiritual aspects of human experience" (Jackson, 1990, p. xxxvi).

One consistent and enduring dimension in a SEARCH mathematics classroom is a child-centered approach. A child-centered approach is characterized by the encouragement of democratic, caring, ethical, respectful, self-directing, self-organizing, and socially-relational principles (cf. Noddings, 1992). A view of control and freedom in a classroom is constituted by a democratic outlook akin to Dewey's reform agenda that advocated self-control as the aim of the educative process. Children's freedom to search together to establish autonomy and independence are major facets of learning mathematics.

Such is the focus of SE in SEARCH. The social dimension of constructing mathematics knowledge is precipitated by a community engendered with a freedom based upon interdependence. From this perspective, an emancipatory purpose imbued with self-control and respect for others becomes fundamental as Social Emancipation in the SEARCH heuristic.

The AR in SEARCH Children's mathematical thinking should revolve around efforts not to tell them the answer but to let them negotiate meaning for themselves and amongst themselves, to build upon their previous knowledge, and to be viewed individually as unique learners with unique ideas. The aim is to provide a learning environment in which children are unencumbered in their search to construct mathematical meaning. The environment should be built upon sociocultural and sociomathematical norms which in turn determine the tenor of the classroom experiences.

The emergent nature of such a reflexive *relationship* is also reflected in the perspective of actively engaging children in their mathematical experiences. The learning environment should be characteristically activity-based, hands-on, participative, and interactive. A sociomathematical norm constituted through an expectation that mathematics lessons should be an active use of time, space and thinking to develop mathematical ideas should prevail. Not only is cognitive growth to be addressed, but also social, emotional, and physical development activated. The teacher's role is not to "teach" children but to facilitate experiences that provide for active engagement in the construction of mathematical ideas. Learning is based upon active engagement in mathematics lessons, on a working relationship and alliance with the principles of partnership and friendship, not just at an inter-active level but also in an intra-active sense. Children are expected to utilize all their senses and capacities intra-actively, in *relationship*, in a holistic fashion to think mathematically.

In consonance with constructivist perspectives that knowing is active, and that it is based on previously constructed knowledge, teachers should reject the structuring of mathematics lessons upon the transmission of instrumental and procedural rule-oriented thinking. Instead, establishing interdependent learning wherein the construction of mathematical knowledge harmonizes in a reflexive relationship between group interaction and individual sense making should be stressed. This reflexive view of learning offers a vantage point from which to address some of the complexities of prevailing theories of mathematics education. Such a vantage point implies that knowledge construction is not purely a personal experience but constitutive of an active participation in a dynamically volatile environment wherein effective engagement implies self-directed harnessing of contextual variables rather than submission to a blind faith of an imposed direction determined by the teacher. Students should be encouraged to resolve perturbations not only through reflection but also through a feeling of confidence in searching for resolutions. Thus student's sense making is portrayed not only as an active and confident foray into new conceptualizations or propositions but also, and importantly, a search sustained by points of conceptual reference which are already constructed as "sensible" and meaningful. Meaning making and confidence go hand in hand, each building the other. From such a perspective, the AR aspect highlights that "Active Referencing" is a constructive inter- and intra-activity in the meaning-making process, engaging reflection and meta-cognition.

The CH in SEARCH In his search to explain human development Piaget's guiding question was, "How does knowledge grow?" In his wisdom, he eventually remarked, "The essential functions of intelligence consist in understanding and in inventing. . . . It increasingly appears, in fact, that these two functions are inseparable" (1971, pp. 27-28). His book "To Understand is to Invent" (1973) is testimony to his revelations that invention is construction. Children consistently like to be, and should be encouraged to be, creative. Teachers need to orchestrate opportunities for creative endeavour during mathematics lessons. Such a motive is based on the assumption that through creating, children construct mathematical knowledge. Considerable time in mathematics lessons should be dedicated to children inventing new ways and uniquely creative mathematical propositions for discussing, validating, expressing, and describing.

Children's personal mathematical sense making should revolve around an environment that is

conducive to spontaneous and creative activity. Establishing such an environment engenders a patience and tolerance for children's freedom. In order to foster children's capacity to express unique ideas children should be allowed to roam the room with autonomous flexibility. Their freedom can be based upon a sociocultural norm that during group time, as long as they respect each other's attempts to complete the projects assigned, they are free to sit, cluster, or gather to work wherever they wish. Such a fluid environment often depicts a state of chaos during mathematics sessions. However, as Jantsch (1980) suggested, the self-regulation of the class endures in systemic order because "the more freedom in self-organization, the more order" (p. 40). The driving force for learning, according to the emerging views of New Science, 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 (1929/1978) believed that the "ultimate principle" of reality itself was a process of becoming and perishing. He contended, 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 of the pupil's mind as "a growing organism" and that "the only avenue towards wisdom is by freedom in the presence of knowledge" (1929/1967, p. 30). For him, ideas "give power to create, to bring into actual existence an infinitude of possibilities. . . . For this reason it is not only good we, as teacher and students, throw 'ideas into every combination possible'; it is essential we do so. For in this 'throwness,' meaning, experience, reality are created" (Doll, 1993, p. 145).

Conclusion A key element of the SEARCH heuristic is captured in an essence of creative opportunity; namely, that growth, development, knowledge, and wisdom occur when there is "balance between the creative opportunity freedom can give and the knowledge we acquire from discipline" (Doll, 1993, p. 147). It is time that educators consider each teacher's efforts to encourage and orchestrate opportunities for children to be independent and self-regulating mathematical thinkers. An approach constituted by a complex set of emergent and reflexive classroom relationships fostering cooperation, freedom, and personal agency generates a positive disposition towards creative thinking, which in turn bolsters children's confidence in taking risks and developing ownership of their ideas. Similarly, by encouraging children to generate novel suggestions and invent unique ways of explaining their mathematical thinking, a community of active mathematical negotiators develops, which in turn fortifies children's progress towards confidence to be even more creative and more adventurous when expressing, justifying or refuting mathematical propositions.

SEARCH implies that the mathematics teacher's role has less to do with being an authoritative transmitter of objective and immutable mathematical information and more to do with empowering children in their search to construct viable mathematical meaning. By honouring constructivist principles that infer that mathematical knowledge cannot be transmitted but is personally and actively constructed, the mathematics program which incorporates the SEARCH heuristic is constituted by a more child-centered and less teacher-directed imperative.

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