

Family Maths and Complexity Theory

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Abstract

The importance of family involvement is highlighted by findings that parents' behaviours, beliefs and attitudes affect children's behaviour in a major way. The Family Maths programme, which is the focus of this study, provides support for the transformative education practices targeted by the South African Department of Education by offering an intervention which includes teachers, learners and their families in an affirming learning community. In this study participating parents were interviewed to investigate their perceptions of the Family Maths programme mainly in terms of their engagement, enjoyment and confidence levels. The major themes and ideas that were generated in this study include the development of positive attitudes, parents and children working and talking together, and the skills exhibited by Family Maths facilitators. These findings are analysed within the parameters of complexity science and the pre-requisite conditions for developing a complex learning community, viz. internal diversity, redundancy, decentralized control, organised randomness and neighbour interactions.

Introduction

Early-childhood studies reveal that, when it comes to children's cognitive development outcomes, parents' behaviours are more important than other highly publicised factors such as daycare arrangements (Belsky, Vandell, Burchinell, Clarke-Stewart, McCartney & Owen, 2007). In the light of these findings, Bouffard and Weiss (2008) stress the importance of reframing family involvement within a complementary learning framework (one that directly supports what is being taught in schools) across ages and settings through the co-constructed efforts and shared responsibilities of many stakeholders. However, historically investment in family involvement in schools has been limited and usually consists of parents assisting teachers in their classrooms, chaperoning, and parent-teacher conferences (Bouffard & Weiss, 2008). These approaches and roles still persist in schools despite research findings that demonstrate that family involvement should be broader and is most authentic and effective when it is 'linked to learning' (Henderson, Mapp, Johnson & Davies, 2007).

The Family Maths programme, which is the focus of this study, provides support for transformational education practices targeted by the South African Department of Education (2002; 2003), but goes further by extending these efforts beyond the school walls to the community at large through offering a creative education practice that impacts on teachers, learners and their families. The data generated have been analysed through the lens of complexity theory in an attempt to interrogate and understand what conditions influence parents' engagement, enjoyment and confidence levels and enable the development of the complex learning community that we attempt to create when bringing together parents, children and teachers in the Family Maths collective.

Complexity science

Complexity science first arose in the mid 20th century as a result of the confluence of cybernetics, systems theory, artificial intelligence and non-linear dynamics (Davis & Simmt, 2003). Events such as the collapse of stock markets, the sudden spread of ideas in society, the collapse of communism in the Soviet Union and Eastern Europe, the rise of life on Earth, shoals of fish which change direction at the same time, etc. are not only examples of what has been of interest to complexity scientists, but are phenomena that have provided the stimulus for the continued emergence of the study of complexity (Waldrop, 1992). A complex system is seen as something greater than the sum of parts, it is the product of the parts and their interactions – something that is self-organising and can adapt (Capra, 2002; Johnson 2001). Complexity scientists describe this type of self-organising phenomenon as a 'learning system'. As such, Davis and Simmt (2003) describe complexity science as the science of learning systems. These authors understand learning in terms of the "adaptive behaviours of phenomena that arise in the interaction of multiple agents" (Davis & Simmt, 2003: 137) and suggest that complexity science is defined more in terms of its objects of study than in its modes of investigation. In this study, the object of study is the beliefs that parents have of what influences their levels of engagement, enjoyment and confidence in mathematics while participating in the Family

Maths programme; a programme which is envisaged as a complex learning system with multiple agents, viz. parents, children, teachers and the ideas they create.

There are several necessary but not sufficient conditions that need to be met for complex systems to arise and maintain themselves (Davis & Simmt, 2003). These conditions, which have been adapted from Bloom (2000), Casti (1994), Kelly (1995) and Lewin and Regine (2000), are internal diversity, redundancy, decentralised control, organised randomness and neighbour interactions. Internal diversity reflects the different ways in which members of a community can respond and interact. Redundancy is the complement of diversity, i.e. redundancy is the ‘sameness’ of the individuals within a system. This ‘sameness’ in a learning community may be a factor of knowledge, purpose, background, etc. Redundancy in this sense may be recognised by the participants’ degree of commonality of expectation and purpose and is essential to triggering a transition of *me’s* to a collection of *us* (Davis & Simmt, 2003). Lewin and Regine (2000: 28) call the area of intersection between redundancy (commonality) and internal diversity as the “zone of creative adaptability”, a notion somewhat similar to Vygotsky’s (1978) ‘zone of proximal development’ in that both ideas refer to immediate possibilities for co-activity, but which are limited by certain criteria.

Another condition that is necessary but not sufficient for systems to evolve and maintain themselves is decentralised control; a situation where power and authority are distributable, the locus of learning is the individual, the system itself ‘decides’ what is and what is not acceptable, and understandings and insights are co-specified and shared. The condition of organised randomness is the delicate balance between enough organisational control to direct activities, and enough randomness to allow flexible and varied responses. Within the notion of organised randomness, Davis, Sumara and Luce-Kapler (2000) coined the term ‘liberating constraints’, i.e. those that are not too prescriptive (such as ‘turn to page 17 and do the geometry examples number 1-7’) or too open-ended (‘write down everything you know about geometry), but something more enabling such as ‘tell me what you consider to be the five most important things about geometry’. Finally, there are agents within a complex system that affect ideas and activities. These agents are termed neighbour interactions. In the sense of complexity theory and learning communities promoted by Davis and Simmt (2003: 156) these ‘neighbours’ are not “physical bodies or social groupings”, but “ideas, hunches, queries and other manners of representation” which must “bump” against one another. It is the interaction of concepts and understandings that make possible a mathematics learning community.

In this paper we attempt to position parents’ perceptions of what influences their levels of mathematics engagement, enjoyment and confidence within the frameworks of complexity science. We do this in order to better understand the influences of necessary, but not sufficient, conditions required for the development of the complex mathematical learning community we wish to promote. A clearer understanding of these influences should also better inform future practices and positions that aim at promoting family involvement in children’s education and developing complex family-oriented learning communities.

The Family Maths programme

The ‘Family Math Program’, which was conceptualised and designed at the Lawrence Hall of Science in Berkeley, California as a subset of the EQUALS programme (which aims at promoting mathematics for all, but particularly amongst girls and minority groups) is designed to allow meaningful links to be made between school and home learning via cooperative learning strategies (Thompson & Mayfield-Ingram, 1998). The ‘Family Maths’ programme, which has operated in South Africa since 1996 is an adapted version of the American precursor, but similarly aims at dispelling negativity toward mathematics and encouraging learners, parents and other family members to translate new experiences and concepts into workable solutions through discussion and the use of hands-on, minds-on, process-oriented, inquiry-based activities (Kreinberg, 1989).

Negative sentiments about visiting their children’s schools are often voiced by parents, particularly in the context of previously disadvantaged schools in poor South African communities (Austin & Webb, 1998), and therefore a less publicised, but nevertheless underpinning, aim of the programme is to bring to the school ‘hard-to-reach’ parents who mostly have only experienced the negative contexts of teacher and principal’s complaints about their children’s weak performance, poor attendance, bad behaviour, etc. At each Family Maths workshop there are usually four or five stations where mathematical activities are displayed. At each station a teacher, who has been trained in inquiry-based teaching and learning strategies, facilitates the activity. The facilitators are trained in techniques to

encourage learners, their parents and other community members to engage, explore and discuss the problem at hand. This is to be done by asking questions, rephrasing the problem statement, giving clues when necessary, and by asking probing questions to direct participants' discussion and thinking. As there is a paucity of data on the effects of family orientated educational programmes in South Africa in general, and on maintaining parental involvement in particular, this study examines parental perceptions of what they believe encourages and promotes their level of engagement, enjoyment and confidence.

Methodology

The study focused on a 'convenience' sample (Grinnell & Unrau, 2005) of volunteer parents (n=12) out of a total of 140 parents/family members of intermediate phase (grade 4-6, age 10-12) learners who participated in a series of seven quarterly Family Maths workshops. The workshops were implemented in urban, peri-urban and rural primary schools in the Eastern and Southern Cape. All parents interviewed were English second-language speakers with either Xhosa or Afrikaans as their first language. Open-ended discussions with all parents prior to the first workshop revealed a high level of negativity towards, and fear of mathematics. At the conclusion of each Family Maths workshop, volunteer parents were given an opportunity to reflect on their experiences at the workshop, their attitude towards mathematics, and their perceptions of facilitators' inquiry-based teaching and learning skills. Data were collected by means of semi-structured interviews which enabled the generation of first-hand, in-depth, rich, unexpected and relevant information from the interviewee (Kvale, 1996). The researchers felt that individual, rather than focus group interviews, should be conducted as individual interviews would probably enable parents to express their perceptions and feelings honestly, while group interviews may be intimidating for some parents who might feel pressured to concur with others in the group.

Data analysis

The interview questions focused on the first three consecutive stages of the five stage model of the inquiry approach to instruction which is outlined by Layman (1996). These three steps for each problem activity include engaging participants, allowing participants to explore, and encouraging participants to explain mathematical concepts. The interview responses were recorded *verbatim* and then coded via an inductive process that involved breaking up and categorising text to form descriptions and broad themes (Creswell, 2005).

Ethical measures

In this study ethical measures included assurance of anonymity and obtaining the informed consent of interviewees. The aims of the study, research design and methodologies were communicated to all (Mouton, 2001). The participants were told that they could withdraw from the process at any stage and that their decision to participate or not to participate would in no way be viewed negatively by the programme facilitators or the researchers.

Results

Overall, the data suggest that the common thread running through the participants responses was '*a sense of achievement*'. The facilitators' approach was the most important factor in making the parents' feel comfortable during the Family Maths sessions. Every parent interviewed noted directly or indirectly that they were happy to ask questions regarding the problem-solving activities. The fact that the facilitators also encouraged and enabled the participants to work in teams was also noted, e.g. "*I enjoyed working as a team*", "*The teacher encouraged me and my daughter to try different ways of solving the problem*" "*The teacher gave us a hint and we solved it together*", "*I enjoyed working in a team, helping each other and asking questions. I felt comfortable.*", and that the "*How do you know that?*" questions by their peers really helped them reflect and develop their understanding of the problem.

Each parent interviewed said that the facilitator had assisted them to solve the problem by engaging them in one or more of the following ways; encouraging them, making them feel relaxed, and not rushing them (42%); explaining clearly what the problem was, asking questions and giving clues when they needed them (42%); not giving them the answer or telling them how to solve the problem, but encouraging them to keep trying (16%). These responses, amongst others, suggest that encouragement, clear explanations, and the fact that the facilitators were not willing to give the participants the answers, but allowed enough time for them to engage sufficiently with the problem,

can be identified as themes running through the parents' perceptions of successful engagement in the Family Maths process.

All parents said that the facilitator had encouraged them to explore the concept in one way or another. Parents gave the following reasons for being encouraged to explore the concept; teachers asked questions which made them think and gave clues when they needed them (50%); teachers gave them time to think and keep trying and they did not feel as if they were being rushed (36%); and they had tried different ways of solving the problem (14%).

It appears evident from the data analysis that the majority of parents who participated in the Family Maths programme entered the programme with minimal knowledge or experience in inquiry learning. This finding was deduced from parental statements such as "*After a workshop I had learnt new ways of thinking*", while another said, "*We are learning maths we did not do at school*".

Discussion

The major themes and ideas that were generated in this study were those of developing a sense of achievement; being encouraged; feeling comfortable; working in a team; engaging in activities with others, skilful questioning by the facilitators; using concrete examples; developing new ways of thinking; and learning maths they did not do at school (novelty). The respondents' references to challenges and engaging with one another, signs of exploratory talk, identification of facilitator skills, and the fact that they noted that these activities influenced their self esteem, suggest that most of the pre-requisite conditions for developing a complex learning community were met in the workshops. Comments by the participants that they were empowered because they felt that their ideas counted suggest that there was sufficient redundancy within the group for believable judgements to be made by their peers, children and facilitators. The fact that they expressed ideas that others appreciated, indicates that there was sufficient internal diversity within the groups for this condition to be met while parents' comments on the facilitators' ability to question skilfully, use concrete examples effectively, introduce a sense of novelty and get them go about thinking about things differently suggest that the facilitation process did promote organised randomness and that the facilitators were able to provide sufficient liberating constraints for a community of learning to emerge.

While issues of internal diversity and redundancy are easily considered to be inherent characteristics of the group membership, it is tempting to believe that the condition of decentralised control is a product of the facilitation process. However, our observations suggest that in this study the collective emerged and sustained itself through shared projects (activities) and neighbour interactions, not through planning or other deliberate strategies. This possibility is supported by the research of Buchanan (2000), Johnson (2001) and Varela (1987) who argue that complexity theory allows different perspectives on what influences the development of a learning community, perspectives opposed to the tendency to suspect the existence of a coordinating agent, something which is probably rooted in habits of cause-effect thinking. These perspectives provide different pointers as to what can be done to promote the emergence of complex learning communities, and allow different interpretations of outcomes.

Understanding the dynamics of interactions, and an awareness of the necessary, but not sufficient, conditions which have influence in the emergence or non-emergence of a learning community are not merely useful tools for post-activity analysis of classroom events, they can also be used to structure engagements with learners (Davis & Simmt, 2003). When structuring engagement, the notion of internal diversity suggests the need to develop activities that can be adapted by learners to their particular knowledge, understandings and interpretations. Redundancy points to the need for shared experiences and clear terms of engagement. Decentralised control and organised randomness highlight the need for careful planning in terms of prescription and awareness of liberating constraints, while neighbour interactions focus attention on how ideas might be represented and juxtaposed.

It is accepted that even if all conditions for complexity are met, there is no assurance that complex possibilities will arise (Davis & Simmt, 2003). On the other hand, it is reasonable to expect that if they are not met, a complex learning community will, to a high level of probability, not emerge. For this reason, we believe that thinking in terms of complexity deepens our understanding of the dynamics within programmes such as Family Maths and raises the chances of influencing the emergence of a complex community of learning. In turn, we believe that there is a better chance of improving parents' understandings, beliefs and attitudes in terms of promoting their children's

educational development and their own participation in educational family life if they are able to engage with their children and their teachers within a complex learning community, such as the collectives envisaged by the Family Maths programme

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