# Developing inquiry-based teaching and learning in Family Maths programme facilitators

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*The inquiry-based Family Maths professional development programme, offered by the Nelson Mandela Metropolitan University, attempts not only to support the transformative education practices targeted by the South African National Department of Education, but also to extend them beyond the school walls to the community at large. This study investigates the extent to which this programme develops facilitators' ability to implement inquiry-based learning. The research undertaken uses both qualitative and quantitative methods in an empirical study of 39 facilitators. The facilitators' inquiry beliefs and ability to implement inquiry learning was measured by means of questionnaires, observation schedules and interviews. Data generated by the study reveal that both the facilitators' understanding and practice of inquiry improved as they progressed through the novice, intermediate and veteran categories of the Family Maths professional development programme.*

## Introduction

The Family Maths programme was conceptualised and designed at the University of California, Berkeley during the late 1970s (Kreinberg, 1989) and has been adopted by various universities, non-governmental and governmental organisations in a number of countries around the world. Examples of these countries include Canada, Australia, New Zealand, Sweden, Costa Rica, and Puerto Rico (Thompson, 2005). In South Africa, the Family Maths programme has been offered by the Co-operative Organisation for the Upgrading of Numeracy Training (a Johannesburg-based NGO), the University of the Free State and the Nelson Mandela Metropolitan University. The overall aims of the intervention programme are to redress inequalities in the schooling system, to dispel negativity towards mathematics, to make school mathematics relevant to learners in their everyday lives, and to promote an inquiry-based approach to teaching and learning (Damerow, Dunkley, Nevres & Werry, 1984; Thompson & Mayfield-Ingram, 1998).

Since the new South African dispensation of 1994, recently revised National Curriculum Statements have aimed at transforming heavily entrenched, traditional approaches and replacing them with a new vision for education based on the introduction of Outcomes-Based Education. These practices are to a large extent underpinned by constructivist and inquiry-based philosophies of teaching and learning (Moll, 1994). However, despite the fact that the facilitation of inquiry learning is a core methodology promoted in South African Revised National Curriculum Statements (Department of Education, 2002), research suggests that traditional teacher-centred practices and rote memorisation of algorithms remain common practice in many mathematics classrooms (Taylor & Vinjevold, 1999).

The Family Maths programme, as offered by the Nelson Mandela Metropolitan University in South Africa, not only attempts to support the transformative education practices targeted by the department of education, but also to extend them beyond the school walls to the community at large. This is done by offering a creative education practice that provides opportunities for teachers, parents, learners and community members to solve problems through discussion and the use of hands-on, minds-on, process oriented, inquiry-based activities in a relaxed, non-threatening environment. This empirical study was undertaken in an attempt to determine the extent to which this programme is able to develop inquiry learning practices and skills in Family Maths facilitators.

## Background

The international Family Maths programme attempts to eliminate much of the pressure, anxiety and fear of failure experienced by both parents and their children, to secure parental and community involvement in learners' education, and dispel the misperception that school mathematics is unrelated to a child's everyday experience (Thompson & Mayfield-Ingram, 1998). The programme adopts an inquiry learning approach which supports interactions amongst learners that focus on

problem-solving (Llewellyn, 2005), and which encourages learners from diverse backgrounds to participate fully in the learning process (National Science Education Standards, 1996). The programme in general also aims to develop the language necessary for meaningful communication in mathematics, develop problem-solving skills and increase confidence and enjoyment of the subject (Kreinberg, 1989).

Although all Family Maths programmes throughout the world adhere to the basic principles described above, adaptations are made from time to time to accommodate local contexts, both in emphasis and execution. In the case of the Family Maths programme at the Nelson Mandela Metropolitan University, there are two contextual demands. Firstly, it must respond to the issue of second-language teachers, learners and parents, and secondly, the university's ability to respond to requests from teachers, principals, departmental official and donors to offer the programme more widely is limited by staff capacity.

The response to the issue of limited staff capacity has been to 'train' Family Maths facilitators in both rural and urban sites in the Eastern Cape (East London) and Western Cape (George and Beaufort West) in South Africa. The professional development course gives facilitators the opportunity to engage in inquiry-based experiences and to develop higher order thinking skills as they ask questions, conduct problem-solving activities, and interpret and discover solutions while constructing mathematical understanding. This study investigates the effect of the Family Maths approach on the ability of facilitators (teachers and teacher educators) to facilitate inquiry-based teaching and learning as they progress through the two-year professional development programme.

In terms of the second-language issue, a 'home-language' approach for group discussions is promoted wherever possible in order to create opportunities for meaningful learner-centred discourse. This approach is considered important, not only because the generic Family Maths programme aims at developing the language necessary for meaningful communication in mathematics, but also because the promotion of classroom discussion has been shown to have a profound effect on children's cognitive development (Wegrif, Mercer & Dawes, 1999; Webb & Treagust, 2006). As such, the promotion of social discourse is central to the modelling process adopted by the Family Maths professional development programme for facilitators at the Nelson Mandela Metropolitan University.

The research takes place against the backdrop of national concerns regarding poor achievement and negative attitudes towards mathematics (Asmal, 2000; Reddy, 2006). It takes into account the fact that a large number of under-qualified primary and secondary school teachers do not have the knowledge and skills to teach the subject competently (Asmal, 2000; Taylor & Vinjevold, 1999), which is exacerbated by teaching and learning that takes place in a second language, in under-resourced classrooms (Taylor & Vinjevold, 1999). It also takes cognisance of research findings that teachers in South Africa appear not to communicate attitudes of curiosity, respect for evidence, or critical reflection – qualities that are necessary for the development of higher-order cognitive skills (Enslin, 1990; Webb & Treagust, 2006).

There has also been extensive research in recent years on the relationships between the beliefs of mathematics teachers and their actual practice in the classroom (Brodie, 2001; Ensor, 1998; Ernest, 1989, 1991; Hoyles, 1992; Lerman, 1986, 2002; Pehkonen & Törner, 2004; Thompson, 1992; Skott, 2001a, 2001b, 2004; Speer, 2005; Wilson & Cooney, 2002). Most of these studies focus on the correlation or disparity that researchers have identified between what teachers believe they should be doing in their classrooms (their 'espoused beliefs' or 'professed beliefs') and what researchers infer, based on observational and other data (teachers' practice or 'attributed beliefs'). We also investigate the espoused and attributed beliefs of the participants in terms of inquiry-based teaching and learning.

In the light of the above, the aim of this study is to make a contribution to the many debates regarding the promotion of inquiry-based mathematics approaches in the South African context, and to contribute to the thinking of those who are grappling with, and attempting to rectify, the concerns noted above.

## Design

The research undertaken was an empirical study of 39 facilitators participating in the Family Maths professional development programme. They were assigned to three categories: novice (less than one year's participation), intermediate (one to two years' participation) and veteran (more than two years' participation). The participants were predominantly in-service teachers and teacher educators in the Departments of Education in the

Western and Eastern Cape. The findings were triangulated by comparing the data generated by both qualitative (interview data) and quantitative (questionnaire and observation) instruments.

Firstly, a facilitators' 'inquiry learning belief system questionnaire' was used to measure the participants' inquiry beliefs and understandings of aspects of the inquiry process. The questionnaire focused on the first three steps of the inquiry process, namely, engaging the participants, allowing them to explore the concept, and encouraging them to explain mathematical concepts and terms. Their ability to implement inquiry learning was measured by using observation schedules to observe and record their inquiry skills while they conducted Family Maths workshops for teachers, learners and parents. One research instrument is based on the 'workshop interaction coding system observation instrument' which measures the extent to which the facilitators use inquiry verbal feedback techniques during interactions with participants (Brophy & Good, 1970). The 'workshop observation instrument' was used to measure the facilitators' ability to capture and focus participants' attention on critical parts of the problem-solving process. Attempts were made to minimise the participants' perceptions of what was being measured, because knowledge of what was 'expected' might change their behaviour. The contents of the observation instruments were therefore not revealed, in order to create as authentic a setting as possible.

Semi-structured interviews with facilitators, using standardised, open-ended questions, provided opportunities to use probing questions to obtain clarity and additional information from the interviewees' responses. This yielded deeper insights into their beliefs and perspectives on inquiry-based learning, their understanding of mathematical problems, and their perceptions of their own inquiry-learning facilitation skills.

Quantitative statistical data were generated from the facilitators' inquiry learning belief system questionnaire (n=88) and the workshop observation instrument (n=39). These data were analysed and subjected to analysis of variance (ANOVA) techniques to provide descriptive and inferential statistics. Comparisons were made between statistically significant mean facilitator scores across the three categories of facilitators in each of the three stages of the inquiry process. All three measures of statistical significance – where $p \leq 0.01$ (highly significant), $p \leq 0.0$ (significant) and $p \leq 0.1$ (weakly significant) – were used for clarity. However, all differences at $p \leq 0.1$ are considered as 'statistically significant in this report. Quantitative data were generated from the workshop interaction coding system instrument (n=39) and qualitative data were generated through the semi-structured interview schedules (n=39). These data were analysed and classified according to broad categories to provide descriptive and inferential statistics. The data generated by the three groups (novice, intermediate and veteran) were compared and subjected to statistical analyses wherever possible.

## Results

Data analysis of the belief questionnaire, workshop observations and semi-structured interviews with facilitators indicates that their inquiry beliefs and practices improved over time as they progressed from the novice to veteran category. There is also clear evidence that the majority of facilitators who first embark on the Family Maths programme appear to have very little knowledge or experience

| **Criteria** | **Group mean scores** | | |
|---|---|---|---|
| | **Novice** | **Intermediate** | **Veteran** |
| Encourages initiative (1b) | 3.45 | 3.70 | 3.88 |
| Encourages questioning (2c) | 3.18 | 3.58 | 3.50 |
| Poses contradictions (2e) | 3.05 | 3.63 | 3.45 |
| Allows time after questions (2f) | 3.30 | 3.60 | 3.50 |
| Seeks elaboration (3a) | 3.14 | 3.35 | 3.63 |
| Participants refine explanations (3d) | 3.12 | 3.65 | 3.63 |

**Table 1.** Comparison of respondents' mean scores with regard to questions on the belief system questionnaire.

| Criteria | Probability Values | | |
|---|---|---|---|
| | **Novice** | **Intermediate** | **Veteran** |
| Encourages initiative (1b) | | | |
| Novice | - | 0.0595* | 0.0286** |
| Intermediate | 0.0595* | - | 0. 4126 |
| Encourages questioning (2c) | | | |
| Novice | - | 0.0198** | 0.1871 |
| Intermediate | 0.0198** | - | 0.7678 |
| Poses contradictions (2e) | | | |
| Novice | - | 0.0207** | 0.0215** |
| Intermediate | 0.0207** | - | 0.5182 |
| Allows time after questions (2f) | | | |
| Novice | - | 0.0295** | 0.3141 |
| Intermediate | 0.0295** | - | 0.6498 |
| Seeks elaboration (3a) | | | |
| Novice | - | 0.0938* | 0.0090*** |
| Intermediate | 0.0938* | - | 0.1767 |
| Participants refine explanations (3d) | | | |
| Novice | - | 0.0002*** | 0.0122** |
| Intermediate | 0.0002*** | - | 0.9091 |

* = statistically significant at the 90% level of confidence
** = statistically significant at the 95% level of confidence
*** = statistically significant at the 99% level of confidence

**Table 2.** Comparison of probability values indicating statistically significant differences between facilitator mean group scores for criteria on the belief system questionnaire for inquiry learning.

in terms of inquiry learning as a teaching and learning strategy, despite this being a strategy recommended for all teachers by the South African government (Department of Education, 2002). It is also clear that in all categories of comparison (veteran, intermediate or novice), the facilitators' inquiry workshop implementation strategies did not always support their stated belief system regarding inquiry learning.

**Belief as measured by questionnaires**

Analysis of the mean scores of the data generated by the four-point scale beliefs questionnaire reveals a statistically significant difference between the three groups of facilitators in terms of engaging participants in problem situations, allowing participants to explore the concept, and encouraging participants to explain the concepts and define mathematical terms. The statistically significant mean scores of the novice, intermediate and veteran groups are indicated in Table 1. The statistical significance (p values from ANOVA) of the differences between the groups is shown in Table 2

It is evident that there is a statistically significant difference in the mean value in each case between the novice group of facilitators and one or both of the other two groups of facilitators who have been participating on the programme for a longer period of time. These data suggest that the facilitators' understandings (beliefs) of inquiry learning improved – in that they became a better match of what is expected – as they progressed from the novice through intermediate to veteran categories of the Family Maths programme. In other words, the novice group of facilitators held an inquiry belief system which was the least developed in terms of the criteria which are indicators of teachers who will probably promote inquiry learning the most effectively. In all cases the veteran and intermediate groups of facilitators

were more advanced in their understanding of what best promoted inquiry learning.

**Teacher practice as measured by observations**

The data generated by means of the workshop observation schedule were analysed statistically to provide descriptive and inferential statistics. The mean scores for each criterion were calculated and comparison of the mean scores of the three facilitator categories suggested a progression in both understanding and implementation of inquiry learning strategies as they proceeded through the two-year Family Maths facilitator professional development programme.

Brooks and Brooks (1993) outline a five stage instructional model for assessing inquiry teaching according to the goals of the National Science Education Standards. Each stage comprises characteristics of teaching according to inquiry-based education. The workshop observation instrument used in this study was adapted from the first three stages of this model to the learning cycle approach to instruction which is outlined in *Science for Life and Living* by Layman (1996).

As noted above, the workshop observation instrument assessed the first three consecutive steps of the five-stage model in relation to the inquiry process, namely, the extent to which the facilitator promoted inquiry learning by engaging the participants (Step 1), allowing participants to explore the concept (Step 2), and encouraging participants to explain the concept and define the terms (Step 3). The facilitators' competence in each of these steps was rated on a scale of one to four. The following coding representations were used, namely, (1) poor or no implementation of inquiry criteria; (2) limited implementation of inquiry criteria; (3) satisfactory implementation of inquiry criteria; and (4) implementation of inquiry criteria that exceeds expectations.

The mean scores for each criterion in each of the three inquiry learning steps were calculated and are shown in Table 3 (Step 1: engages the participants), Table 4 (Step 2: allows participants to explore) and Table 5 (Step 3: encourages participants to explain the concept). Mean scores and levels of statistically significant differences are indicated in Tables 6 and 7 respectively.

No statistically significant differences were recorded for a number of criteria, indicating that levels of competence observed during the workshops were similar for all facilitators. However, comparison of the mean scores still suggests that progression is made as facilitators proceed from novice through to veteran category. Criteria which showed no statistically significant differences included: 'creates a relaxed, non-threatening environment' (1a); 'uses manipulative, interactive and physical materials' (1b); 'allows participant responses to drive lessons, shift instructional strategies and alter content' (2a); 'encourages participant inquiry by posing thoughtful, open-ended questions' (2b); 'encourages participants to question each other' (2c); 'engages participants in experiences that pose contradictions to their initial hypotheses' (2d); 'allows time after posing questions' (2e); 'seeks elaboration of participants initial responses' (3a); 'encourages use of cognitive terminology such as classify, analyse, predict' (3b); and 'asks probing questions to elicit meaningful explanations' (3c).

The probability levels of confidence for criteria that are statistically significantly different are shown in Table 7 and suggest a progression in understanding and implementation of inquiry learning strategies as facilitators proceed through

| **Criteria for Step 1** | **Group mean scores** | | |
|---|---|---|---|
| | **Novice** | **Intermediate** | **Veteran** |
| Creates a relaxed environment | 2.97 | 3.00 | 3.21 |
| Encourages student autonomy | 2.60 | 3.10 | 3.14 |
| Uses materials (manipulatives) when teaching | 3.30 | 3.22 | 3.14 |
| Familiarises self with particular understanding | 2.40 | 2.70 | 2.86 |
| Encourages participants' discussion | 2.47 | 2.50 | 2.93 |
| Nurtures participants' natural curiosity | 2.40 | 2.50 | 2.86 |

**Table 3.** Comparison of mean facilitator scores, across facilitator categories, on their ability to engage participants in problem-solving activities.

| Criteria for Step 2 | Group mean scores | | |
|---|---|---|---|
| | Novice | Intermediate | Veteran |
| Allows particular responses to drive lessons | 2.47 | 2.70 | 2.64 |
| Poses thoughtful, open-ended questions | 2.40 | 2.50 | 2.79 |
| Encourages participants to question | 2.13 | 2.30 | 2.43 |
| Poses contradictions in initial hypotheses | 2.13 | 2.40 | 2.38 |
| Allows time after posing questions | 3.20 | 3.00 | 3.07 |
| Focuses and supports inquiries | 2.71 | 3.00 | 3.21 |
| Sum of mean scores | 15.04 | 15.90 | 16.52 |

**Table 4.** Comparison of facilitator mean scores, across facilitator categories, on their ability to allow participants to explore concepts.

the sequence of stages of novice, intermediate and veteran categories.

***Step 1: Engages the participants***

During this stage the facilitators were expected to introduce activities that engaged learners and parents with a problem or phenomenon. These types of activities are expected to provide participants with an open-ended opportunity to interact with the materials and each other and are also aimed at capturing participants' interest and enabling them to make connections with what they know and can do. As such, the 'Step 1' section of the workshop observation instrument attempts to identify the degree to which the facilitator engaged the participants in the problem-solving activity according to specific criteria, as shown in Table 3.

***Step 2: Allows participants to explore the concept***

Step two of the National Science Education Standards (1996) model of inquiry instruction identifies the degree to which the facilitator allows participants to explore the concept of the problem-solving activity according to specific criteria. Mean scores for each group of facilitators for the second step of inquiry learning were calculated from the data generated by the workshop observation schedule (Table 4).

***Step 3: Encourages participants to explain the concept and define the terms***

Step three of the National Science Education Standards (1996) model identifies the degree to which the facilitator encourages participants to explain the concept and define the terms related to the problem-solving activity, according to specific criteria. Mean scores for each category of facilitators for the third step of inquiry learning were calculated from the data generated by the workshop observations schedule (Table 5).

**Overall mean scores for practices observed**

The mean scores for the workshop observations in general, which includes all three steps of the

| Criteria for Step 3 | Group mean scores | | |
|---|---|---|---|
| | Novice | Intermediate | Veteran |
| Seeks elaboration of particular responses | 2.47 | 2.60 | 2.79 |
| Encourages use of cognitive terminology | 2.13 | 2.00 | 2.29 |
| Asks probing questions | 2.27 | 2.60 | 2.64 |
| Gives opportunity to refine explanations | 2.20 | 2.40 | 2.64 |

**Table 5.** Comparison of facilitator mean scores, across facilitator categories, on their ability to encourage participants to explain the concept and define the terms.

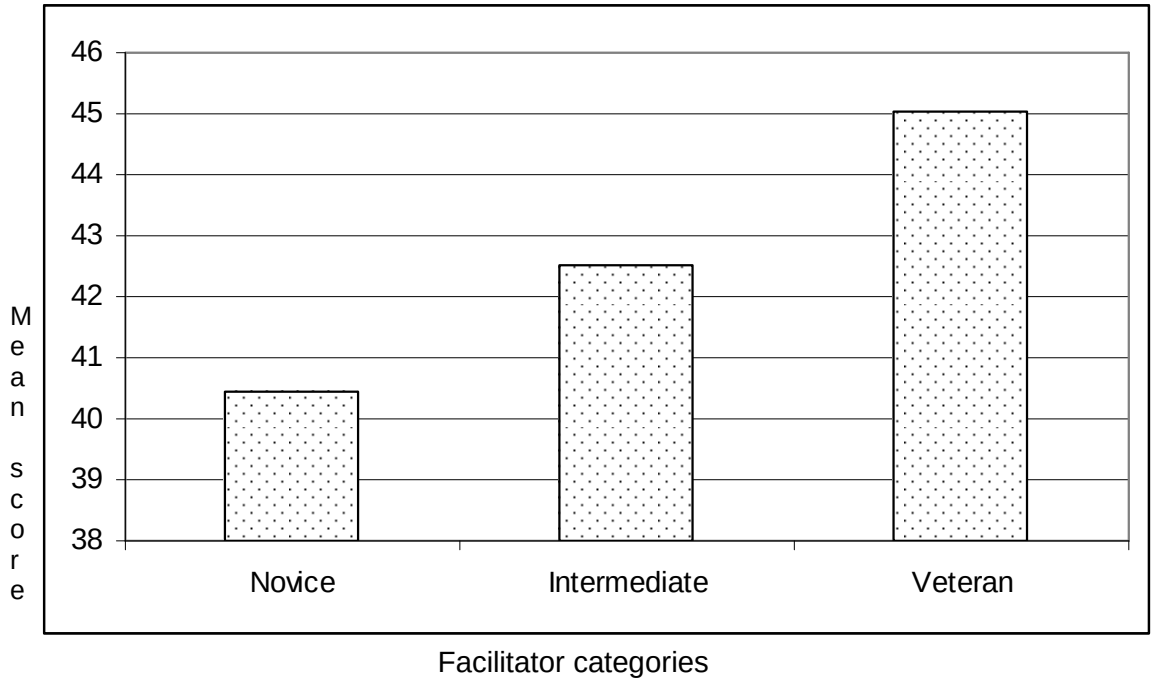


**Figure 1.** Overall mean scores of novice, intermediate and veteran groups in terms of inquiry-based practice.

National Science Education Standards inquiry model are indicated in Figure 1. Findings suggest a steady progression in the implementation skills of the facilitators on the Family Maths professional development programme as they advance through the sequential stages from novice, to intermediate, to veteran.

### Analysis of variance

Statistical analyses (ANOVA) of the data generated by workshop observations reveal that there were no statistically significant differences between the veteran, intermediate and novice groups for all criteria (see Tables 3, 4 and 5). However, there were statistically significant differences between the three categories in terms of 'encouraging and accepting student autonomy and student initiative' (1b), 'familiarising themselves with the participants understandings of concepts' (1d), 'encouraging participants to engage in discussion with the facilitator and one another' (1e), 'nurturing participants natural curiosity' (1f), 'focusing and supporting inquiry while interacting with the participants' (2f), and 'giving participants opportunities to refine their explanations and definitions' (3d). In each case the veteran group

| **Criteria** | **Group mean scores** | | |
|---|---|---|---|
| | **Novice** | **Intermediate** | **Veteran** |
| Encouraging autonomy (1b) | 2.60 | 3.10 | 3.14 |
| Participants understanding (1d) | 2.40 | 2.70 | 2.86 |
| Engaging discussion (1e) | 2.47 | 2.50 | 2.93 |
| Nurturing curiosity (1f) | 2.40 | 2.50 | 2.86 |
| Focussing/supporting inquiry (2f) | 2.71 | 3.00 | 3.21 |
| Refining explanations (3d) | 2.20 | 2.40 | 2.64 |

**Table 6.** Comparison of statistically significant different mean scores for criteria observed during facilitation of Family Maths workshops.

| Criteria | Probability Values | | |
|---|---|---|---|
| | **Novice** | **Intermediate** | **Veteran** |
| Encourages autonomy (1b) | | | |
| Novice | - | 0.0056*** | 0.0012*** |
| Intermediate | 0.0056*** | - | 0. 8047 |
| Participants' understanding (1d) | | | |
| Novice | - | 0.2002 | 0.0355** |
| Intermediate | 0.2002 | - | 05046 |
| Engages discussion (1e) | | | |
| Novice | - | 0.8842 | 0.0391** |
| Intermediate | 0.8842 | - | 0.0712 |
| Nurtures curiosity (1f) | | | |
| Novice | - | 0.6715 | 0.0386** |
| Intermediate | 0.6715 | - | 0.1409 |
| Supports inquiries (2f) | | | |
| Novice | - | 0.0825* | 0.0016*** |
| Intermediate | 0.0825* | - | 0.1886 |
| Participants refine explanations (3d) | | | |
| Novice | - | 0.3061 | 0.0160** |
| Intermediate | 0.3061 | - | 0.2218 |

* = statistically significant at the 90% level of confidence
** = statistically significant at the 95% level of confidence
*** = statistically significant at the 99% level of confidence

**Table 7.** Probability values which indicate statistically significant differences between mean scores for criteria observed during facilitation of Family Maths workshops.

scored the highest and the novice group the lowest. These data are reflected in Table 6. The mean scores recorded show a sequential increase, and the statistical significance between these scores is portrayed in Table 7.

Table 7 reveals probability values at the 90%, 99% and 95% levels of confidence between the novice and intermediate groups and between the novice and veteran groups respectively. These indicate significantly different levels in the ability of facilitators to encourage and accept student autonomy and initiative as an important inquiry strategy as they progress through the two year Family Maths professional development programme. There is also a significant difference at the 95% level of confidence between the veterans' and novices' ability to familiarise themselves with the participants' understandings of concepts. The veteran group of facilitators show a much higher level of competence in familiarising themselves with workshop participants' understanding of concepts than the novice group of facilitators.

In terms of encouraging participants to engage in discussion with the facilitator and one another, the statistically significant difference between the veterans and novices is at the 95% level of confidence. The data for the category 'nurturing participants' natural curiosity' shows a statistically significant difference between the veterans and the novices. There is a similar level of confidence between the scores of the veteran and novice group in terms of 'focusing and supporting inquiry while interacting with the participants'. The difference between the veterans and the novices in 'giving participants opportunities to refine their explanations and definitions' is also significant at the 99% level of confidence.

| | Novice | | Intermediate | | Veteran | |
|---|---|---|---|---|---|---|
| | Belief | Practice | Belief | Practice | Belief | Practice |
| Engage | 3.39 | 2.58 | 3.62 | 2.83 | 3.70 | 3.02 |
| Explore | 3.15 | 2.42 | 3.34 | 2.65 | 3.48 | 2.76 |
| Explain | 3.16 | 2.38 | 3.45 | 2.53 | 3.56 | 2.69 |
| Total | 9.70 | 7.38 | 10.41 | 8.01 | 10.74 | 8.47 |

**Table 8.** Comparison of facilitator mean scores with regard to inquiry learning belief versus practice.

**Comparison of mean scores between facilitators' inquiry learning belief system and implementation of inquiry learning**

Of the three categories of facilitators, the novices show the least amount of understanding regarding inquiry learning (belief) and have the lowest rating with regard to implementation of inquiry learning strategies (practice). The intermediate group of facilitators generally show a greater understanding than the novice group and also implement inquiry learning more effectively in the workshop situation. The veteran group of facilitators show the greatest understanding of inquiry learning and also show the greatest skill in the implementation of inquiry learning strategies.

Table 8 represents the mean scores of each of the categories of facilitators with regard to their inquiry belief system and their implementation of inquiry learning. In order to compare what facilitators say they believe regarding inquiry learning with their implementation skills of inquiry learning in the workshop situation, mean scores were given for each of the categories in terms of their ability to encourage participants to engage in the problem-solving situation, explore the concepts and explain the concepts and terms.

**Comparison of beliefs and practices**

The novices' belief questionnaire responses suggested that they had the least understanding of inquiry learning, and observation of novices practice revealed that they also have the lowest rating with regard to implementation of inquiry learning strategies. The veteran group of facilitators showed the greatest understanding (belief) of inquiry learning, and also showed the greatest skill in the implementation of inquiry learning strategies (practice). These data are represented graphically in Figure 2.

In all categories of comparison in figure 2 the probability value is less than 0.05 ($p \leq 0.05$) and there is, therefore, a 95% level of confidence that the statistical differences between the mean scores of the belief system questionnaire and the workshop observation instrument scores are not due to chance. It can therefore be concluded that in all categories – novice, intermediate and veteran – facilitators' stated inquiry belief systems are

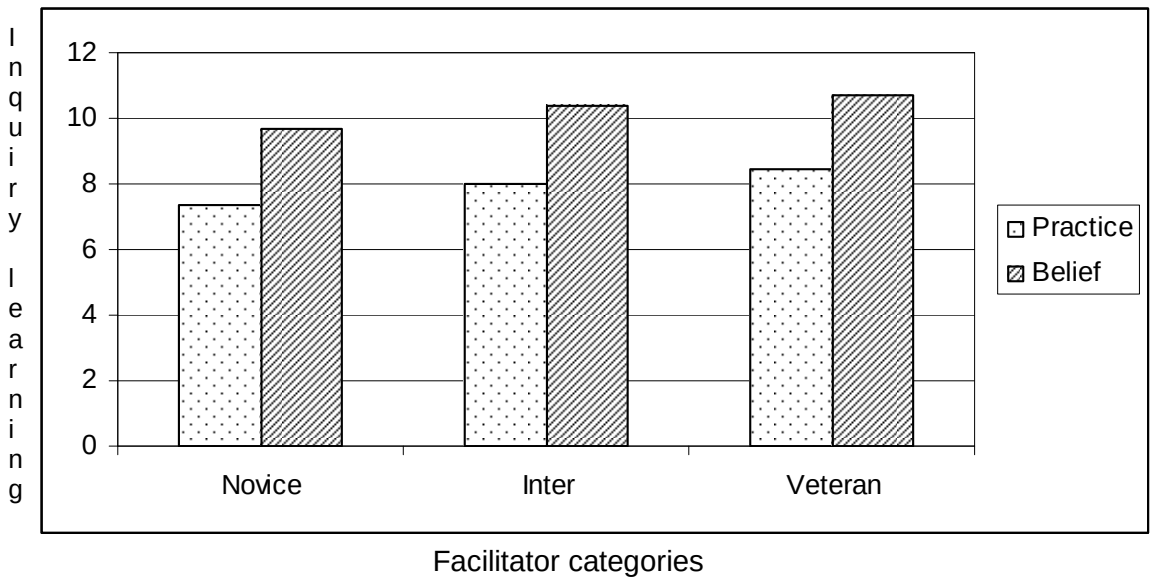


**Figure 2.** Comparison of participating facilitators' beliefs and practice in terms of inquiry learning.

expressed to a lesser degree in their workshop implementation.

### Facilitators' verbal responses measured by Workshop Interaction Coding System Instrument

The facilitators' verbal feedback techniques were measured using the Brophy and Good 'dyadic interaction coding system'. This instrument was used to classify answers, questions, clues and rephrasing of questions. It provides a coding sheet against which the facilitators' verbal feedback techniques are recorded. Analysis of these data revealed that across all categories of facilitators, higher order responses of 'giving clues' and 'rephrasing questions' were more frequent amongst facilitators than merely 'repeating questions'. These findings are encouraging, as the Family Maths programme strongly discourages giving answers to participants.

### Interviews

The data generated via interviews were classified into broad categories and analysed within the framework of reviewed literature. The responses from facilitators of the intermediate and veteran groups suggest that the majority felt confident in terms of implementing inquiry learning because they believed that the Family Maths programme had been effective in developing their questioning skills and their ability to give meaningful clues. However, a large number of novice group facilitators felt that they had not mastered the skills of 'questioning' or 'giving clues' and would benefit from further training in this regard.

Most of the facilitators from the intermediate and veteran categories acknowledged that inquiry-based learning had changed their way of teaching both in the workshop situation and in the classroom. One novice facilitator gave the following response: "I still find it hard to move away from the teacher-centred approach". Intermediate and veteran facilitators gave responses such as: "inquiry learning has changed my way of teaching" and "inquiry-based learning has made me think differently about my own teaching strategies".

## Discussion

The apparent disjuncture between the facilitators' beliefs and practices may be of concern to some. However, while some researchers have suggested that beliefs are a major force in affecting teaching practice (Schoenveld, 1992; Thompson, 1992), others assert that they are not (Hoyles, 1992). Skott (2001a) maintains that mathematics teachers can simultaneously hold multiple, and possibly conflicting, beliefs about their practice in the course of classroom interaction. This view implies that understanding of the micro aspects of the classroom, such as classroom atmosphere and interactions between the teacher and specific groups of learners are essential to the understanding of differences between their beliefs and practices. As such, it would be interesting and profitable to investigate and interrogate the reasons that the facilitators in this study give for the apparent disjuncture between their beliefs and practices, and use these explanations as a framework for developing a more grounded professional development programme.

More definitively, analysis of the data generated by the questionnaire, observation schedules and interviews suggest that facilitators' understanding of inquiry improved as they progressed through the novice, intermediate and veteran categories of the Family Maths programme. However, on occasions, the intermediate category of facilitators achieved slightly higher mean scores than the veteran facilitators (see Tables 1, 3, and 4). One possible explanation is that while intermediate facilitators participate in regular training workshops and benefit from regular support from Family Maths trainers, many of the veteran facilitators – on successful completion of the two professional-year development programme – conduct Family Maths workshops independently, without ongoing support from the trainers. There is, therefore, a possible tendency for veteran facilitators to regress to the more traditional beliefs which they may have held over a period of many years. Regression after exposure to new teaching and learning strategies is fairly common in educational research literature (Webb, 1992). This notion of regression suggests that the need for ongoing support for facilitators after completion of the Family Maths professional development programme is a factor that should not be underestimated.

Encouragingly, data analysis of the verbal response techniques of facilitators indicates that only one percent of both the novice and intermediate groups of facilitators succumbed to giving participants solutions to problems before participants had been given the opportunity to solve the problem within the group situation. None of the veteran facilitators gave solutions to the participants; they persevered by repeating the question, giving clues and rephrasing the question. This is particularly significant in light of the fact

most of the participants were themselves not educated in inquiry-based methodology, nor trained to teach in these ways; many found that making the paradigm shift was not as overwhelming as they initially thought. Most participants learnt to combine inquiry-based teaching and learning strategies with the creation of a relaxed, non-threatening environment. It appears that confidence and self esteem increased as facilitators and participants actively challenged and engaged with one another, thereby honing their interpersonal and verbal skills during the learning experience. Findings of this nature are echoed by the reports of Mercer, Wegerif and Dawes (1999), Abrami, Chambers, Poulsen, De Simone, D'apollonia and Howden (1995), and a number of other researchers focussing on discussion and exploratory talk. For these reasons it seems that the active promotion of classroom discussion techniques should be highlighted as an important aspect of continuous professional development programmes in order to break the cycle of teacher-centred practices and rote learning.

Interview, questionnaire and observation data all indicate that facilitators' perceptions, attitudes and abilities with regard to inquiry learning developed as they proceeded through the facilitator categories of the Family Maths programme. The emphasis of the programme on inquiry techniques and active engagement is particularly relevant to the implementation of the new South African outcomes based education curricula, which are underpinned by constructivist and inquiry-based approaches to meeting curriculum outcomes.

## Conclusion

The findings of this study suggest that the Family Maths professional development programme at the Nelson Mandela Metropolitan University can promote the ability of teachers and teacher educators to engage in multiple aspects of inquiry-based teaching and learning over the two-year course. This in turn implies that appropriately selected aspects of the approach have the potential to assist in the design of other teacher development programmes aimed at dispelling negativity towards mathematics and making school mathematics more relevant to learners.

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"Those who are accustomed to judge by feeling do not understand the process of reasoning, because they want to comprehend at a glance and are not used to seeking for first principles. Those, on the other hand, who are accustomed to reason from first principles do not understand matters of feeling at all, because they look for first principles and are unable to comprehend at a glance."

***Blaise Pascal***