A systematic approach to evaluating mathematics teaching methodologies in an International Private School in Dubai

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ABSTRACT

The purpose of this report is to demonstrate the employment of a systematic approach to evaluating mathematics teaching methodologies and curriculum in a private international school in Dubai. The primary and junior school mathematics teaching pedagogy will be exclusively identified through a combination of various methodologies such as: a teacher questionnaire, an evaluation of the KHDA government inspection report, an examination of the current mathematical program (New Heinemann Math Scheme), an investigation of students' ability levels (based on grade 5 ISA (ACER) scores) and an analysis of teachers' behavioral patterns from individual and group year level and mathematics coordinator meetings. The major findings indicate that mathematics teachers mainly use traditional didactic teaching methodologies. Little evidence suggests the use of incorporating other teaching strategies such as constructivist, discovery learning, technology or the use of concrete aids within their lessons. Results indicate that student's 'low mathematical literacy' scores are due to insufficient coverage of mathematical content and their lack of diversity to incorporate different teaching methodologies. This report recommends that teachers at the International School should participate in formal and informal professional development sessions and appoint a curriculum coordinator who will manage the overview of curriculum through good leadership practices, thereby assisting teachers with planning, implementing and evaluating units and programs to increase student achievement.

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Table of Contents

Table of Contents ____ v

Chapter 1. Introduction ____ 1

1.3 Research Questions ____ 3

Chapter 2. Background ____ 5

2.1 The private international school in Dubai ____ 5

Table 1 Summary of students and teachers at the private international school in Dubai 6

2.2 Knowledge and Human Development Authority (KHDA) ____ 7

2.3 Australian Council for Educational Research (ACER) ____ 9

Table 2 ISA Mathematic Literacy score comparison ____ 10

Chapter 3. Review of Literature ____ 12

3.1 Reforms in Mathematics Education ____ 13

3.2 Teaching Mathematics Pedagogies ____ 16

3.2.1 Didactic Teaching ____ 16

3.2.2 Constructivist Teaching ____ 18

3.2.3 Discovery Learning ____ 21

3.2.4 Technology ____ 21

3.2.5 Differentiation ____ 25

Figure 1 Teaching approaches from Professional Handbook provided by DEET, state of Victoria, Australia 2001 ____ 26

3.2.6 Use of Concrete Aids for Understanding Mathematical Concepts ____ 26

3.3 Organisational Behaviors Associated with Change ____ 28

Figure 2 Fullan's (2001) Framework of Leadership ____ 29

Chapter 4. Methodology ____ 32

4.1 Respondents ____ 32

4.2 Research Objectives ____ 33

4.2.1 Study A: Identify Teachers' Pedagogy ____ 33

Figure 3 Identify teachers' pedagogical styles ____ 33

4.2.2 Study B: Curriculum Investigation ____ 33

Figure 4 Analysing the grade 5 Heinemann New Math scheme ____ 34

4.2.3 Study C: Methodology Investigation ____ 34

Figure 5 Identify a correlation between teaching methodologies and students' low ICA scores ___ 35
4.2.4 Study D: Implementation of a New Curriculum ___ 35
Figure 6 Analysis of maths meetings during curriculum reform using Fullan's theory _ 38

4.3 Development of the Survey ___ 38
Table 3 0–4 time rating scale ___ 39
Table 4 Teacher survey questions and their intended purpose ___ 46

4.4 Pilot Study of the Survey ___ 46

4.5 Data Collection of the Survey ___ 47
4.5.1 Limitations of Close-ended Questionnaires ___ 47

4.6 Document Analysis ___ 48

4.7 Group and Individual Meetings ___ 48
4.7.1 The Aims of the Group Meetings ___ 49
4.7.2 Limitations of Individual and Focus Group Meetings ___ 53

Chapter 5. Analysis of Findings ___ 54

5.1 Study A: Results from Survey ___ 54
Figure 7 Teachers' years of teaching experience ___ 55
Figure 8 The average use of didactic teaching methods during instructional time ___ 56
Figure 9 Amount of time children are engaged in constructivist or discovery learning 58
Figure 10 Amount of time teachers use technology in mathematics lessons ___ 61
Figure 11 How often do children work in differentiated groups? ___ 62
Figure 12 Amount of time teachers use concrete aids during mathematics lessons __ 64

5.2 Study B: Results of Curriculum Investigation ___ 64
Table 5 Grade 5 ISA concepts children scored lowest in and math concepts not covered ___ 67
Table 6 Grade 5 ISA concepts children scored higher in and math concepts covered 69

5.4 Study C: Results of Methodology Investigation ___ 69

5.5 Study D: Results of Implementation of a New Curriculum ___ 71
Table 7 The teachers' reaction to mathematics curriculum reform ___ 72

Chapter 6. Conclusions ___ 77

6.1 Overall Conclusions ___ 77
6.1.2 Study A: To identify teachers' pedagogy and compare it to the KHDA inspection report. ___ 77
6.1.3 Study B and C: Curriculum and methodology investigation ___ 77
6.1.4 Study D: Implementation of a new curriculum ___ 78

6.2 Recommendations ___ 79

6.3 Future Research ____ 80

Chapter 7. References ____ 82

Appendix One ____ 90

Appendix Two ____ 92

Session One ____ 92

Session Two ____ 94

Session Three ____ 94

Session Four ____ 95

Session Five ____ 98

Session Six ____ 99

Appendix Three ____ 101

Appendix Four ____ 105

Chapter 1. Introduction

Teaching is the oldest and most important profession in the world. A child's education is one of the main pillars of creating a sound and progressive society. From the 1800s to the present day the standards of practice for the teaching profession have evolved. Teachers facilitate the development of students who contribute to the greater society and therefore need to understand student development, learning theories, pedagogy, curriculum and ethics. In addition, educators need to continuously refine their professional practice through ongoing inquiry, reflection, collaboration and knowledge.

In the past, educational authorities have employed two main methods ensuring educational institutes internationally provide the highest quality of education. These include inspecting schools and developing student assessment tasks that benchmark their attained knowledge. Few governing bodies have used a questionnaire methodology to determine and validate observations conducted by inspection authorities. The Australian Council for Educational Research (ACER) developed an International Schools Assessment (ISA) that aims to internationally assess students and allows institutes to evaluate and benchmark students' abilities against 'all other like schools' and 'other international schools'. In the United Kingdom, the Office for Standards in Education (OFSTED) has been successfully inspecting schools since 1992, and has contributed to an improved quality of teaching and learning.

The United Arab Emirates have recently followed suit. In 2008, schools in Dubai experienced their first inspection by the Knowledge and Human

Development Authority (KHDA). In September 2008, the private international school in Dubai was assessed; everything from the management structure to classroom teaching and learning was observed and reported. The KHDA observations informed the headmaster of the teachers' didactic approach to teaching, especially in mathematics; they reported that there was too much emphasis on completing pages in a textbook and not enough 'hands-on' active learning. The school was given 18 months to improve its teaching methods. Shortly after the inspection, in February 2009, students at the private international school took part in the ISA program and the results revealed that students in levels 4, 5 and 6 scored lower than 'all other like schools' and 'other international schools' in the area of mathematical literacy.

Inspection reports and student scores are the predominate forms of assessing the success of an educational institute. Few studies have adopted a systematic approach to evaluating schools. In the United Arab Emirates, this approach in this form has not been used before. The purpose of this research is to identify current teaching methodologies through the combination of means such as:

- a questionnaire
- an analysis of government inspection reports
- an examination of the current mathematical program (New Heinemann Math Scheme)
- an analysis of students' ability levels (based on grade 5 ISA scores)
- an analysis of teachers' behavioral patterns from individual and group meetings as they undergo the initial stages of a mathematics reform.

This study has three main aims:

1. Identify current math teaching methodologies and determine their relation to the results of KHDA (Knowledge and Human Development Authority) inspection.

2. Investigate results of student ISA (ACER) tests and analyse the private international school in Dubai's teaching methodologies and their current Math program.

3. Analyse teacher behavior during curriculum reform in relation to Dalin (1978) and Dalin et al (1993) four core barriers to change: value, power, psychological and practical, and Fullan's (2001) framework of leadership, in order to gather a deeper understanding of teaching methodologies at the private international school in Dubai.

Recommendations are also made that will assist the school to improve the quality of their teaching and learning in the subject of mathematics.

1.3 Research Questions

1. What are the current teaching methods of primary mathematics? Do teachers practice current/best teaching methodologies?

2. Does the KHDA (Knowledge and Human Development Authority) inspection report support data gathered from the teacher questionnaires and highlight similar mathematics teaching and learning strengths and weaknesses?

3. What has the ACER (Australian Council for Educational Research) International schools assessment report identified about student achievements in mathematics? Are student results linked to teaching methodologies and/or the current Math scheme?

4. Does a mathematics curriculum reform emphasise teachers' beliefs and methodologies?

Chapter 2. Background

2.1 The private international school in Dubai

The private international school in Dubai has been established since 1991. It provides a broad international education and offers extensive facilities including sports fields and PE halls, theatre, art rooms, IT computer and science labs, and primary/junior and secondary school libraries. At the beginning of this study (January 2009), the school practiced the following protocol documents which informed teaching and learning: New Mathematics Heinemann Scheme – for mathematics, The Collins Scheme – for English, and International Primary Curriculum (IPC) – for integrated studies. This paper will only focus on the area of mathematics teaching and learning.

The school caters to children from kindergarten through to high school, including primary school and junior high; this alone is indicative of the school's size. The campus provides clear divisions for each age group, hence the timetabling of lessons and breaks is well organised. For the purpose of this paper, only the primary and junior school sectors are investigated.

School overview:	• Primary, junior and high school mixed gender (except for PE in junior and high school) • Age range 5–18
Number of primary and junior school students:	• K-6 year levels multiplied by six classes in each level • Total of 42 classes • Each class consists of approximately 25 students (42 × 25) • Total of 1,050 students
Nationality of students:	• 80 mixed international nationalities
Staff members:	• Principal • Junior school deputy principal • Primary school deputy principal • 42 classroom teachers (international nationalities) • 2 computer teachers • 1 library teacher • 2 music teachers • 4 physical education teachers • 3 learning support teachers • 2 ESL teachers • All teachers are international

Table 1 Summary of students and teachers at the private international school in Dubai

The school expresses its mission statement quite stridently – it aims ‘to cater to the local and expatriate students to further enhance their educational, social, emotional and physical development, whilst encouraging them to think analytically and creatively in preparation for the next stage of their education’.

According to the School Improvement Plan (2008), the intended strategic plans for 2008-2011 on classroom teaching strategies are:

> ‘5.1 To develop differentiated programs of learning which support best first teaching for all students.
>
> 5.2 To develop critical thinking, problem solving, research, independence and interdependence skills within our learning programs.’

This report investigates current mathematics classroom teaching methodologies at a private international school in Dubai.

2.2 Knowledge and Human Development Authority (KHDA)

HH Sheikh Mohammed Bin Rashid Al Maktoum, Vice President and Prime Minister of UAE, Ruler of Dubai, announced the development of all knowledge and human resource departments in Dubai. It is the KHDA’s responsibility to ensure that the education sector in Dubai is in accordance to the international educational standards.

KHDA is the first government organisation established that inspects all schools in Dubai. KHDA is based on the United Kingdom OFSTED program. The department has developed a process of strategically evaluating each educational setting according to educational standards that will presumably ensure quality teaching. The inspectors visit each institution for approximately four days. They evaluate teaching and learning in the areas of English, mathematics, science, Arabic and Islamic studies. The official examiners also enquire how the leadership and management teams ensure that the children are provided with an environment that protects and supports them socially, emotionally and physically (KHDA, 2009).

KHDA evaluate all schools in Dubai based on seven questions:

> ‘1. How good is the students’ progress?
>
> 2. How good is the students’ personal and social development?
>
> 3. How good is teaching and learning?
>
> 4. How well does the curriculum meet the educational needs of the students?
>
> 5. How well does the school protect and support students?
>
> 6. How good are the leadership and management of the school?
>
> 7. How well does the school perform overall?’

These questions are internationally researched in school effectiveness and provide the framework for an overall rating/level for the performance of the school. The levels are:

> **‘Level 4**: Outstanding quality – exceptionally high quality of performance or practice.
>
> **Level 3**: Good quality – the expected level for every school in Dubai.
>
> **Level 2**: Acceptable – the minimum level of acceptability required for Dubai. All key aspects of performance and practice in every school meet or exceed this level.
>
> **Level 1**: Unsatisfactory – quality not yet at the level acceptable for schools in Dubai. Schools will be expected to take urgent measures to improve the quality of any aspect of their performance or practice that is judged at this level.’

The private international school in Dubai was rated ‘Level 2 – Acceptable’. A summary of the report is provided in Appendix One. The KHDA (2009) report suggests that ‘teachers at the school are required to extend their teaching to ensure high quality learning experiences for students and develop children’s capacity for independent learning’. The KHDA confidential detailed report stated that didactic teaching was observed, therefore stating that the teachers were required to extend their teaching and they needed to adopt a range of teaching methodologies.

The first aim of this report is to identify the current teaching methodologies used in mathematics and to ascertain whether or not they are in line with the KHDA results.

2.3 Australian Council for Educational Research (ACER)

The Australian Council for Educational Research (ACER) have developed an International Schools Assessment (ISA) procedure which is based on the Program of International Student Assessment (PISA) framework for reading, mathematical literacy and writing from grades 3 to 10. The purpose of the test is to evaluate instructional programs, provide normative information, compare subgroups and measure individual achievements by monitoring the individual’s and the group’s progress over time.

The private international school in Dubai participated in this assessment for the first time in February 2009. The results of the test were compared to ‘all other schools’ (internationally) and ‘other like schools’ (local schools within Dubai) and analysed according to a standardised ISA scale (which provides the standard deviation in order to identify significant differences or relationships).

The results of the study revealed that the mathematical literacy was lower than ‘all other schools’ and ‘other like schools’. For the purpose of this study, the results of grade 5 mathematical literacy will be analysed. The report for the grade 5 students is below:

Domain		***Mathematical Literacy***		
		n	***mean***	***S.D***
All	This school	147	314	(76)
All	All other schools	2225	387	(86)
All	Other like schools	532	373	(86)
Males	This school	79	327	(82)
Males	All other schools	1036	392	(88)
Males	Other like schools	282	376	(86)
Females	This school	68	299	(66)
Females	All other schools	1189	381	(84)
Females	Other like schools	250	369	(86)
English speaking background	This school	57	342	(76)
English speaking background	All other schools	913	387	(81)
English speaking background	Other like schools	186	393	(89)
Non-English speaking background	This school	90	297	(71)
Non-English speaking background	All other schools	1312	386	(89)
Non-English speaking background	Other like schools	346	362	(83)

Table 2 ISA Mathematic Literacy score comparison

The private international school in Dubai has between 26% and 40% of students in the school from an English speaking background. ‘Other like schools’ are those with a similar ratio of English-speaking background students to non-English speaking background students. n = number of students. The means are expressed as ISA scale scores. The S.D. (standard deviation) is expressed in ISA scale score points.

> ‘The international grade 5 mean for ‘all other schools’ is 387; the mean for ‘other like schools’ is 373 and this school is 314.

Grade 5 performance is significantly lower (81.6%) than ‘other like schools’ (314/373), as well as ‘all other schools’ (314/387). Both male and female mean scores are lower (327/376 and 299/369) and in line with boys performing better in mathematical literacy than girls. Pedagogical decisions will have to be made about the effectiveness of the grade 5 mathematics literacy program.

81.6% of students have a score below the mean of all ISA grade 5 students. The top score in the grade is 456, while 137 is the lowest student score. The grade 5 students have achieved low scores on the following questions: Questions 23 (adaptation), 30.1 (problem solving), 31 (problem solving), 27 (shape), 20 (graphs), 2 (adaptation), 19 (graphs), 21 (shape), 26 (area), 11 (monetary), 15 (table), 8 (scale), 32 (proportions), 17 (shape), 29 (number pattern), 18 (shape), 2.2 (shape), 22.1 (shape), 10 (interpreting), 14 (line graph), 28 (number pattern).

One Grade 5 class had a zero score on Question 31 (Solve a problem involving proportion using multiplication). These problem areas need to be analysed and have to be included as part of the curriculum for the next academic year. The students have problems with the interpretation of information.’

(Private international school in Dubai, 2009)

The second aim of this report was to investigate the grade 5 mathematical program and teaching methodologies in order to ascertain why student ISA results were lower than ‘other like schools’ and ‘international schools’.

Chapter 3. Review of Literature

The literature review is structured into three interrelated sections.

The first section, reforms in mathematics education, offers a concise analytical perspective on the history of mathematics teaching; the socio-economic influences, in particular, have greatly influenced the mathematics curriculum and its relationship in swaying the teaching practicum. Conducted in the UAE, an international school in Dubai, this research uniquely unfolds the complexities of the past and uses it as a learning curve in explaining the essential needs of classroom teaching in the 21st century: the evolution of teaching mathematics.

The second section critically evaluates the major teaching methods: didactic, constructivist, discovery learning, use of technology, differentiation and the use of concrete aids. The findings and methodologies from past research are compared, and thus contribute to the development of the questionnaire that will be used to determine the teachers' pedagogical beliefs on the nature of mathematics. The analytical evaluation based on fact and evidence, from this small-scale study, will provide information enabling the researcher to present a relevant and educated conclusion.

The third section deals with organisational behaviors associated with change and the differentiation in managing school reforms. These theories will be applied in order to fully understand the teachers' emotional and intellectual responses during the initial stages of the curriculum re-structure. The importance of this section in the study is to determine teachers underlying beliefs about mathematics.

3.1 Reforms in Mathematics Education

Mathematics education has been built upon many theories and much research, which in turn has guided curriculum development. Throughout history, methods and values in our education system reflected the changes in our fast growing socio-economic society. Mintzes and Wandersee (1998) describe studies relating to the last one hundred years and bring into view the three most significant reforms and innovations to education.

The first period, the ‘Practicalist’ (1918-1957), was led by theorists such as Dewey and Thorndike. Their major influence on education was a structured learning system, with the purpose of creating an effective workforce. The pedagogical terms and the theoretical approach to classroom teaching and learning was drill and practice and no explanation to the cognitive structures were considered. Their rationalisation largely contributed to the industrial revolution during this time.

The second era was the ‘Academist’ period from 1958-1977. With an economically profitable society and the government’s introduction of free education, gender equality was prevalent during this period; all this meant a shift towards higher academic achievement. Influential theorists such as Piaget and Skinner dominated this reform and focused on the human cognitive development and behavioural change. Their work, together with Vygotsky, influenced the third era – the period from 1978 to the present day, the ‘Human Constructivist’. Their research identified the importance of social and conceptual learning (Mintez et al 1998).

In effect, curriculum developers have attempted to adhere to the world globalisations and set mathematics policies and innovations, which are taught in classrooms by teachers in order to prepare future generations to successfully lead the nation better than the one before. Handal and Herrington (2003) believe that each reform has been unsuccessful because of the sheer large amount of innovation attempts. Research by Kyeleve and Williams (1996) and Moon (1986) has shown that a top-down method is ineffective because it does not take into account teachers' beliefs and pedagogical practices.

Globally, case studies conducted by Anderson and Piazza (1996), Buzeika (1996) and Sowell and Zambo (1997) have gained insight into this phenomenon of successful implementation of innovations and found that one of the common trends leading to the unsuccessful implementation of mathematics reforms is caused by the mismatch between the curriculum objectives set by policy developers and the actual mathematics instruction taught daily to children in the classroom. Classroom observations conducted by Sparks and Hirsh (2006) found that teachers teach mathematics according to their own academic beliefs, regardless of the innovations forced upon them by educational authorities. This research suggests that in order for classroom teachers to embrace a new educational initiative, they must first gain awareness of their own pedagogical beliefs in order to make changes.

Mathematics teachers from eighth grade classrooms in Hong Kong, Japan, Netherlands, Switzerland, Australia, Czech Republic and the United States participated in a study conducted by the Third International Mathematics and Science (TIMMS) organisation. The teachers claimed to have used reformed methods of teaching mathematics i.e. constructivist methodologies. The findings, based on video recordings of their lessons, revealed that 90 per cent did not incorporate a constructivist teaching methodology but rather displayed evidence of 'chalk and talk', with the teacher being the 'transmitter of knowledge', as demonstrated by the ratio of teacher and student talk of 8:1 words (Hiebert, Gallimore, Garnier, Bogard Givvin, Hollingsworth, Jacobs, Chui, Wearne, Smith, Kersting, Manaster, Teseng, Etterbeek, Manaster, Gonzales and Stingler, 2003).

Battista (1994) believes that teachers are the pinnacle of educational reform, particularly in the case of mathematics, and if they lack content knowledge and understanding then they will resort to teaching mathematics as a set of facts and procedures to be transmitted – as they themselves were taught. Therefore, in order to successfully adopt curriculum initiatives, teachers must develop their content knowledge and challenge their existing mind-set about the nature of mathematics.

Several case studies conducted in the United States by Snow-Renner and Lauer (2005) compared the effect of two groups of teachers on implementing reformed methodologies. One group experienced 80 hours of professional development and the other undertook 160 hours of professional development. They found that the group who experienced more hours of professional development was more likely to use reformed methodologies in their classroom practice. Studies conducted by Wilson and Berne (1999) agree that time spent in professional development is a key element to successful implementation of change.

A study conducted by Yates (2009) found that there was no relationship between teachers' beliefs about mathematics and their beliefs about mathematics teaching and learning, and those teachers who experienced a high number of reforms used ITC and constructive-teaching approaches.

Clearly there have been copious amounts of research into establishing and rationalising strategies for successful mathematics implementation of innovation and reform. The commonality between all of the findings is that it is important to assess each educational institute uniquely and provide individual support to teachers, investing time into educating their technical know-how as well as understanding their underpinning beliefs about the nature of mathematics.

The third aim of this study is to identify and analyse teachers' pedagogical beliefs about the nature of teaching mathematics in a private school in Dubai.

3.2 Teaching Mathematics Pedagogies

Following is a summary of the different approaches to teaching mathematics:

3.2.1 Didactic Teaching

The didactic teaching model is also known as 'formal instruction'. Sfard (1998) defines didactic teaching as the traditional teaching of concepts as basic units of knowledge to be accumulated by the individual. This traditional method of teacher-centred direct instruction places students as passive receptors of knowledge. Researchers have found that didactic teaching is boring and so hinders learning. The caricature here is of a teacher standing in front of the class dictating notes, pursuing their own agenda and failing to engage with the students. However, on the flip side, as stated by Woodheads (2001), a brilliant teacher knows every student in the class and asks the right question at the right time to the right student. Although this methodology can be didactic, in the sense that the teacher is the authority at the front of the class, it can also be liberating if every child is involved using this skill. Woodheads (2001) goes on to explain that if didactic teaching does not engage children in some form of questioning and simply recites notes verbatim then this can certainly obstruct learning.

The researcher, who has seven years experience of teaching mathematics to 6 and 9 year old children, supports Woodhead's view of didactic teaching, especially in the case of such young school-aged children whose attention span is short. Based on the author's classroom practice, teachers need to adopt a range of methods in order to engage children in learning and assist with making connections to the mathematical concepts in order to sustain children's level of concentration. The investigator has found that the didactic approach is only effective if the teacher has a sound knowledge of individual children's ability levels and uses questioning during the instructional period to scaffold and cater for the range of levels, hence engaging and motivating children in learning. Furthermore, experience has highlighted that children who mainly benefit from the didactic teaching approach are usually the middle to high achievers because they have the necessary prior knowledge. The subject of mathematics is proven to be learned most effectively when taught in a hierarchical order of complexity, whereby certain concepts require prerequisite knowledge. The researcher has found that using a didactic approach without sufficient questioning generally only targets a specific ability level of children and thus has proven to place a cohort of children (middle to low level achievers) at a disadvantage.

A study conducted by Stipek, Feiler, Daniels and Milburn (1995) on the effects of different instructional approaches on young children's achievement and motivation compared 227 children aged between 4 and 6; half attended child-centred programs and half attended didactic, highly academic programs. They found that children in the didactic programs scored lower on number achievement tests and had negative outcomes on the motivational measures. Compared to children in the child-centred programs children in didactic programs rated their overall abilities significantly lower, had lower expectations for success on academic tasks, showed more dependency on adults for approval, displayed evidence of taking less pride in their achievements and claimed to worry more about school. (Concrete data produced in the article 'effects of different instructional approaches on young children's achievement and motivation' on page 1.)

Katz (1988 cited in Stipek et al 1995) claims that didactic instruction inhibits intellectual ability directly through fostering superficial learning of simple responses rather than real understanding and problem solving. Although Katz does not define 'real understanding' it is assumed that this is measured by a child's ability to apply mathematical concepts skillfully and thoughtfully to problem solving tasks. Furthermore, teacher-centred instruction emphasises performance which often undermines children's intrinsic motivation for learning, eagerness and willingness to be risk-takers in their learning, whereby children become dependent on the adult authority for solutions.

Didactic methodology of teaching is underpinned by the behaviorist theory of 'drill and practice' and it presents the mind as a 'black box', it does not give any consideration to the cognitive connections of learning. Didactic teaching also views learning as information processing, whereby teachers do not take into account the limited capacity of the working memory and permit students the time to grasp and perform what has been learnt before giving them new information, Slavin (2006).

3.2.2 Constructivist Teaching

The constructivist teaching methodology is supported by theorists such as Vygotsky (1970) and Piaget (1958, cited in Slavin 2006). This approach is based on the belief that learning is an active and constructive process, linking new information to prior knowledge. Unlike didactic teaching, it does not assume that the child is a blank slate and knowledge cannot be developed unless the child makes sense of it according to his or her current conceptions. Therefore children learn best when they are allowed to construct an individual understanding based on experiencing events and ruminating on those experiences.

Constructivist educators and researchers do not know all there is to know about the ideal mathematical instructional strategies, however they have identified common elements of content and pedagogy, thus improving students' learning rates. Raizen (1996, cited in Garet, Birman, Porter, Desimore and Herman 1998), suggests that children learn best when they are active participants, engaging in activities, rather than recipients of lecture-style instruction. The researcher believes that classroom teaching and learning has been the most successful when children are actively engaged, especially when the teacher can skillfully apply a varied level of guidance and work within children's zone of proximal development and scaffold their understanding. The researcher has found that pure constructivist teaching and learning is an ineffective strategy, especially in the case of mathematics, because the low ability children usually fail to make the connection between the mathematical concept and the activity.

The curriculum council for Wales (1989) emphasises the dual nature of mathematics, stating that mathematics is both a body of knowledge and a process of enquiry – a 'product' and a 'process'. Here, there are two views of mathematics teaching. Tanner and Jones (2000) state that, on one hand, it is a *body of knowledge* consisting of facts and rules to be memorised and, on the other hand, it is a *construction of knowledge* for making sense of the world, emphasising creativity, investigation and problem solving. Therefore mathematics teaching needs to incorporate a combination of rote learning (traditional/drill and practice) and rational understanding based on construction of knowledge. The researcher believes that it is important to employ a number of different pedagogical practices to appeal to the diverse range of students. The author's teaching experience has shown that children who have some prior knowledge are able to cope well with less guided inquiry-based learning and display academic gains from the experience. However, those children who do not have the same level of prior mathematical knowledge need direct instruction in order to obtain knowledge before they can benefit from participating in less guided inquiry-based learning.

Kirschner, Sweller and Clark (2006) assemble many compelling arguments which strongly suggest that the guided-constructivist approach is favorable over the pure constructivist methodology. Their research has found that students' knowledge learnt through experience is mainly based on the procedure, rather than the content knowledge, where the emphasis shifts away from teaching a discipline as a body of knowledge, with the emphasis on learning based on experience. Also the exploration practice causes a much larger cognitive load, this means that the working memory cannot take in the heavy load of unguided experiences – this is particularity crucial for novice learners who lack the schemas to incorporate new information into prior knowledge which leads to poor learning. Therefore only the knowledgeable learners will benefit from the constructivist strategy. Kirschner et al (2006) stress the importance of providing novice students with explicit guidance during mathematics problem-solving tasks because they do not have sufficient knowledge in their long-term memory, and through the guided-constructivist approach, the amount and nature of guidance can be relaxed as the students increase their expertise and knowledge in the long-term memory which can take over from the external guidance.

On the contrary, the constructivist methodology is supported by Kolb's (1984) experimental learning model, whereby his research has found that the learning process begins when individuals see the effect of their action, anticipate what would follow from different environments, then understand and apply the general principle. However, one may argue that this would require a level of meta-cognition and is only suitable for those who have previously developed this skill. Critics believe that Kolb's experimental research base for his model was too small and limited mainly to the western culture, therefore lacking in diversity of cultures, gender, ages, socio-economic and educational backgrounds. Furthermore, the nature of Kolb's linear model assumes that all people learn in a neat sequential fashion. The researchers teaching experience has shown that students learning can be quite random and has a tendency to regress through stages and operate in different orders.

3.2.3 Discovery Learning

Kirschner et al (2006) define discovery learning as finding out the solution to a problem in an information-rich environment with minimal guidance by the teacher. Research conducted by Mayer (2004) provides evidence which suggests discovery learning is an ineffective method of assisting children with learning and transferring knowledge. In summary, Mayer (2004) found that the constructivist view of learning is best supported by teaching that involves cognitive activity, rather than the behavioral, and that students learn best with instructional guidance rather than pure discovery approaches. Furthermore he believes that having a specific curricular focus to classroom programs assists students with learning, more than the unstructured student exploration program approach. However, Van Joolingen's (1999) research places importance on discovery learning – as it activates the involvement of the learner creating a better structure and foundation for understanding. He believes that students construct their own knowledge through experimenting in an area and developing an understanding from the results of the experience. According to Van Joolingen, this type of learning is effective because when students create their own experiments within their domain and draw their own conclusion they are constructing their knowledge at a higher level than in an expository learning environment where the information is simply presented to the student.

3.2.4 Technology

Hennessy, Ruthven and Brindley (2005) used 18 focus group interviews with teachers to investigate their beliefs on integrating ICT into classroom teaching. Results show that teachers used ICT in the classroom to enhance and extend existing classroom practice and found that it complemented their teaching. However, their study is limited as it only analyses the opinions of teachers' observations and does not take into account the influence it has on student achievement.

Information Technology permeates all areas of today's society. ICT has been commonly used in classrooms as an 'add on' to regular classroom work and used as a 'tool' to engage children into the learning and consolidating their skills. Clements, Natashi and Swaminathan (1993) state that we are at a crossroad with ITC: some teachers use it to reinforce traditional methods of teaching, rather than implementing it as a means for innovating and supporting the new methods of teaching i.e. collaborative and student-centred environments.

Many researchers have found that ICT does not compliment lessons that are taught in a traditional didactic fashion. Studies by Bracy (1988) have found that effective amalgamation of ICT in the classroom only occurs in settings where teachers and learners engage in collaborative and problem-solving environments, and ICT can then compliment this in authentic learning activities.

Yelland's (2000) conducted a report based on reviewing literature that researched the effectiveness of incorporating technology into mathematical lessons in order to enhance student achievement. The findings from empirical research projects illustrate that effective use of ICT in schools can increase the quality of children's work: it predisposes them to engage with mathematical ideas and gives students the opportunity to learn in new and dynamic ways that were not previously possible without the technologies. Schacter (2000 cited in Yelland, 2000) studied a national sample of fourth and eighth grade students in West Virginia and analysed student achievement when they had access to educational technologies and found that students made positive gains in achievement. Schacter's results were based on the constructed tests, standardised tests and national tests.

There is much literature to support the view that ICT can play a crucial role in collaborative classroom settings, whereby children become more engaged and motivated in their learning. Schofield, Eurich-Fulcer and Britt (1994) found that with the notion of incorporating ICT, students general enthusiasm increased, and it encouraged the children to engage in collaborative learning – meaning computer-based work required a high level of persistence and involvement. Therefore learning environments were more student-centred as students worked within their zone of proximal development and scaffolded on their learning in individual tasks (with guidance from the teacher) or in groups.

Becker (1993) found that teaching children to use mathematic computer programs also enabled them to develop an understanding of operating a computer. The development of these generic computer skills can be incorporated and used across all areas of the curriculum.

Many studies that attempted to establish the link between the effect of ICT and student achievements have been unsuccessful because they failed to consider the environment and teaching methodology employed by the teacher. Callister, Thomas and Dunne (1992) believe that if computers are used to import and amplify poor pedagogy (didactic, traditional-style of teaching) then student learning can be negatively affected. Callister et al (1992) also state that incorporating ITC into the curriculum elevates learning if teachers practice collaborative, guided-constructivist pedagogical methodologies. Furthermore, the degree to which student achievement is successful is dependent on the role of the teacher and their ability to successfully integrate computers into the learning process.

Kulik and Kulik (1991) believe that when assessing the impact of technology on the education process, it is important to see further than its effects on academic learning achievements and explore how employing ICT can change the content, process and context of student learning. Their study, using the Geometry Tutor Program, gathered data showing that students were more enthusiastic and interested in their work, especially with the new dynamics in the classroom, and supported their peers more during the learning process.

Swan and Mitrani (1993) found that computers can assist students to achieve more successful outcomes as their learning becomes more student-centred and collaborative. Their research shows there is significantly more student-centred and collaborative teaching and learning in a computer-based classroom than in traditional classroom settings. Their research highlights the positive impact computers have on the interactions between teachers and students; this suggests that technology unaccompanied with teaching methodologies will not change the schools, rather there has to be a change in teaching pedagogy in order for the use of computers to have an impact on learning.

Mayer, Schustack and Blanton (1999) examined the ways in which computer programs could promote mathematical problem solving transfer in an informal, collaborative environment through an after school program called the Fifth Dimension. Their observations found that children who used an educational software program developed skills in content knowledge, basic computer literacy, and made additional gains within general academic knowledge. The Mayer et al (1999) study supports educational computing environments as it not only assists retention of mathematical facts, it goes beyond and improves children's problem solving/transfer skills. After using this program for a year, Mayer et al analysed these children's general mathematics achievement standardised tests, and in comparison to their peers, the children who attended the Fifth Dimension after school sessions scored higher in mathematical problem solving tests.

3.2.5 Differentiation

Tomlinson (2000) defines differentiation as a mixture of approaches to teaching and learning. Differentiation encompasses the following sets of beliefs:

- Students within each grade level have different interests, styles of learning, experiences and readiness to learn.
- Students learn at different paces and at crucial times need different support from teachers and peers to learn.
- Students learn best when they are encouraged by the teacher and pushed slightly beyond until they can work without assistance (Zone of Proximal Development and scaffolding).
- Students learn best when they can make a connection between real life situations, their interests and the curriculum.

The rationale, sustaining the methodology of differentiation into classroom teaching of mathematics, stems from Vygotsky's 'zone of proximal development' (1970, cited in Slavin 2006) – which is the gap between what the child can perform independently and what he or she can do with the guidance of a teacher – and 'scaffolding' theory – which is the changing level of support a teacher provides as the student becomes more proficient.

Vygotsky explained that learning occurs with assistance of a more knowledgeable person and named the gap between a student's ability to perform a task under guidance of a teacher, or with peer collaboration, and independently as the Zone of Proximal Development. Through careful planning, the class teacher can place children in ability groups (same level of understanding) and provide the opportunities for these students to work in peer collaboration. Therefore through listening to each other's reasoning strategies they become more able to achieve the learning task. Vygotsky also found that scaffolding assisted learning; by providing a great deal of support during the initial stages of student learning and, then diminishing the support and having the child take on the increasing responsibilities until they can perform the task independently. Again this has assisted teachers effective planning through writing down and acknowledging the students who require different levels of support.

Based on my teaching experience, the scaffolding procedure is imperative to mathematical education because if a child is stuck at one level then the teacher is required to look for reasons as to why the child is not moving to the next level. The model below provides a summary of the different teaching approaches:

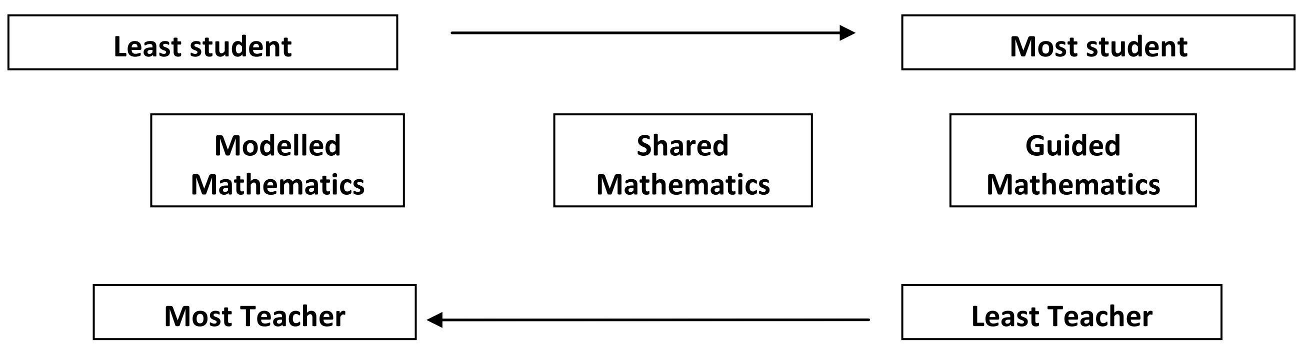

Figure 1 Teaching approaches from Professional Handbook provided by DEET, state of Victoria, Australia 2001

3.2.6 Use of Concrete Aids for Understanding Mathematical Concepts

Using concrete objects and pictorial representations for understanding mathematical concepts dates back to the 1930s. The research in this area has mixed results, however when compared and contrasted many favour using concrete objects to assist with the understanding of mathematics instructions. Plato, a Greek Philosopher, argues that justification distinguishes belief from knowledge. Therefore, in allowing concrete aids to justify mathematical concepts (especially in the younger years) then children can develop their understandings (cited in Kemerling 2006). Sowell (1989) found that using concrete aids was beneficial for primary-aged children but not useful for older children.

A study conducted by Marsh and Cooke, (1996) involved three third grades. These students were first given verbal mathematical problems followed by being introduced to manipulatives such as Cuisenaire rods to set up worded problems. The results revealed that students exhibited immediate improvement after the lesson and were able to answer questions correctly without using manipulatives. However, Marsh and Cooke's small sample size weakened their findings.

Nonetheless, the notion of using concrete aids is supported in Piaget's developmental theory. Piaget (1977, cited in Ojose 2008) states that when children are between 3-7 years, they are in their 'concrete operational' stage of development, whereby they begin to use two or more of their senses simultaneously in order gain understanding. Therefore, hands-on activities allow children to develop their experiences and by manipulating concrete aids they develop their understanding of abstract ideas. Ojose (2008) explains that the rationale here is students use the concrete materials to acquire the experience which lays the foundation for more advanced mathematical thinking. Therefore he believes that using concrete materials enhances the mathematical development of children.

The fourth aim of this study is to identify the current mathematical teaching methods used at the private international school in Dubai and establish correspondence to KHDA's observations, and to ascertain any correlation between students low achievement scores in the ISA test and current teaching and learning practice.

3.3 Organisational Behaviors Associated with Change

Fullan (2001) believes that a culture of change is a tangled web of nonlinearity and creative breakthroughs. He suggests that any transformations made are not possible without the accompanying messiness of anxiety, resistance, fear, loss, improvements, risk-taking and excitement. He suggests that change arouses emotions, and when emotions are running high then a tactful and diverse set of skills and understanding are required.

There are many theories which suggest either top-down or bottom-down processors of leading and understanding change. For example, Kotter (1996) offers an eight step process for initiating top-down transformation, Beer, Eisentat and Spector suggest six bottom-up ideas to change and Hamel (2000) provides eight stages to leading the revolution. However, all of these guidelines assume that managing people and their reactions can be controlled and thus do not provide an understanding of change. Mintzberg, Ahlstrand and Lampel (1998, cited in Fullan 2001) believe when managing change, it is important to allow for it to happen and to deal with concerns as they arise because there is no hard and fast rule to managing reform.

Rather than offering another step by step guide for leading educational reforms, Fullan (2001) focuses on five core aspects which entail developing a new mind-set. Heifetz (1994) supports this image of leadership and believes that it is important to mobilise people to solve problems.

Figure 2 Fullan's (2001) Framework of Leadership

In order to attain successful educational reform the leaders must have an understanding of Fullan's (2001) core concepts.

1. Moral Purpose – leaders are guided with making decisions that encompasses and values the wider community and the wider context.

2. Understanding the change process – leaders develop the mind and action set in order to: not to innovate the most, not have the best ideas, appreciate the implementation dip, redefine resistance, re-culturing, and never follow a procedural checklist, always allow complexity.

3. Relationship building – interactions and relationships are essential to getting results.

4. Knowledge building – when knowledge is shared the relationships are strengthened and motivation is likely to become intrinsic.

5. Coherence Making – once there is the chaotic mess that change brings, then societies can achieve a greater reining in.

Fullan (2001) believes this continuous cycle is better than the hierarchical systems because individuals can easily resort to superficial compliance, which research has shown occurs mostly in educational reforms. Using Fullan's interactive systems, it is unlikely for teachers to get away with superficial compliance without being noticed and hence it will be obvious if students are not contributing.

Keith Morrison (1998) believes that an individual's motivation and reaction to change is determined by the degree to which the change is perceived to be important to them. Dalin (1978) and Dalin, Rolff, Kottkamp (1993) suggest four core barriers to change:

1. Value barrier – change disagrees with ones values.

2. Power barrier – accepting change because it gives greater power or resistance if power is diminished.

3. Psychological barrier – the change challenges their confidence and emotional well-being.

4. Practical barrier – changes threatened to deskill them.

Furthermore Clarke (1994) found that if resistance is a cause of doubt, then the case of change needs to be more compelling; in order to achieve this it needs to be debated and rooted concerns need to be surfaced in order to be dealt with. He also states the rejection of the proposed may occur if:

1. Staff members do not believe it will improve on current practice.

2. Staff members become personally concerned.

3. Unsuccessful results occur due to prior experience.

In order to best manage each of these types of resistances, Clarke's (1994) research suggests that support and motivation will have to be increased and provided to staff through the change process; some staff may require psychological support if they become personally concerned; and all possible causes of unsuccessful results in the past need to be examined.

The fifth aim of this study is to analyse group and individual meetings in order to determine teaching methodologies.

Chapter 4. Methodology

The qualitative and quantitative data will be gathered through:

- a questionnaire
- analysis of government (KHDA) inspection reports
- examination of the current mathematical program (New Heinemann Math Scheme)
- an analysis of students' ability levels (based on grade 5 ISA scores)
- an analysis of teachers' behavioral patterns from individual and group meetings as they undergo the initial stages of a mathematics reform.

As stated by Bell (1999), this approach is called 'triangulation'. By examining the information collected through different methods, the researcher can corroborate data and minimise the impact of potential bias. This application of information assembly – from questionnaires, various documents and meetings – provides the researcher with a balanced selection of evidence ensuring robustness of results.

4.1 Respondents

The respondents selected for this study were K-6 primary and junior school mathematics teachers. In total 42 mathematics teachers participated during different aspects of the study. For example, all staff members were given the opportunity to voluntarily submit the questionnaire – of which 27 responded, and the year level coordinators and math year level coordinators participated in the group meetings.

4.2 Research Objectives

4.2.1 Study A: Identify Teachers' Pedagogy

The first aim of this paper is to use the survey as a quantitative measure in order to determine the teaching pedagogies at the private international school in Dubai and if there is a correlation between the KHDA inspection report and the teachers' responses about their mathematics teaching methodologies.

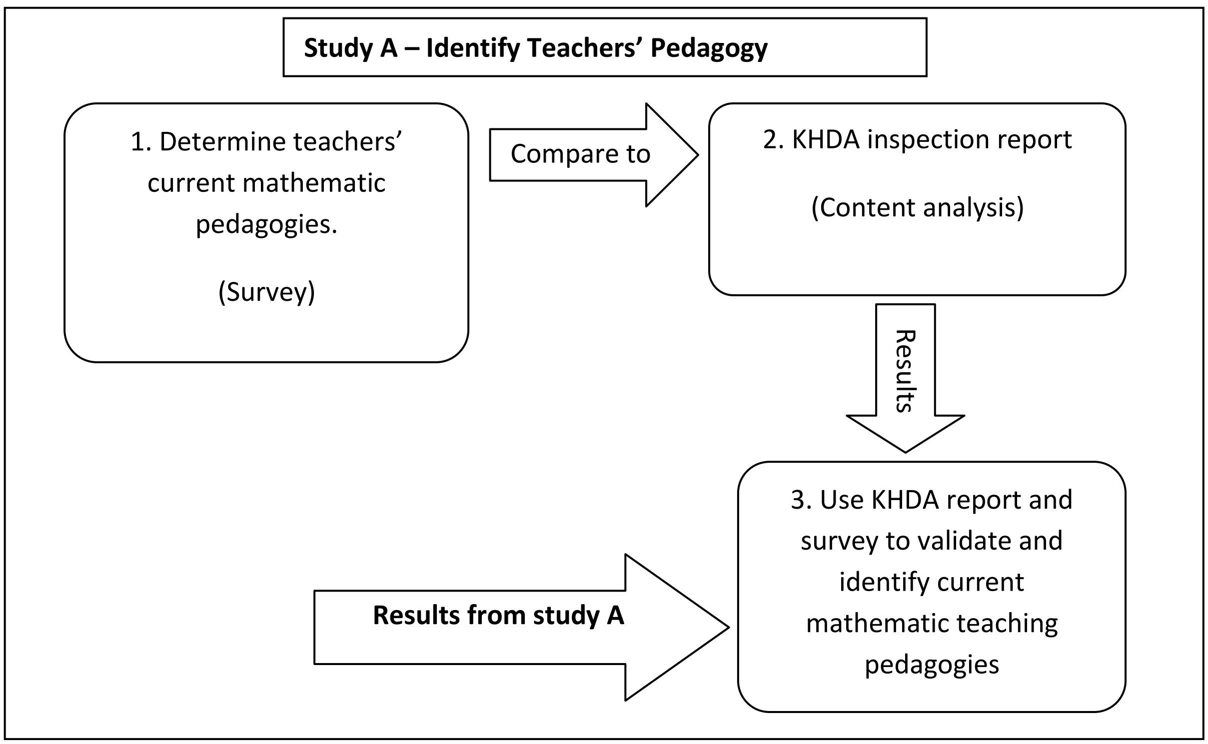

Figure 3 Identify teachers' pedagogical styles

4.2.2 Study B: Curriculum Investigation

The second aim of this paper is to use the ISA grade 5 test results and analyse the mathematical concepts in which children scored the lowest, against the grade 5 New Heinemann Math scheme. The researcher will be comparing and analysing the two documents and tabulating the results. The intent of this research is to use the data and draw possible conclusions as to why children obtained low results.

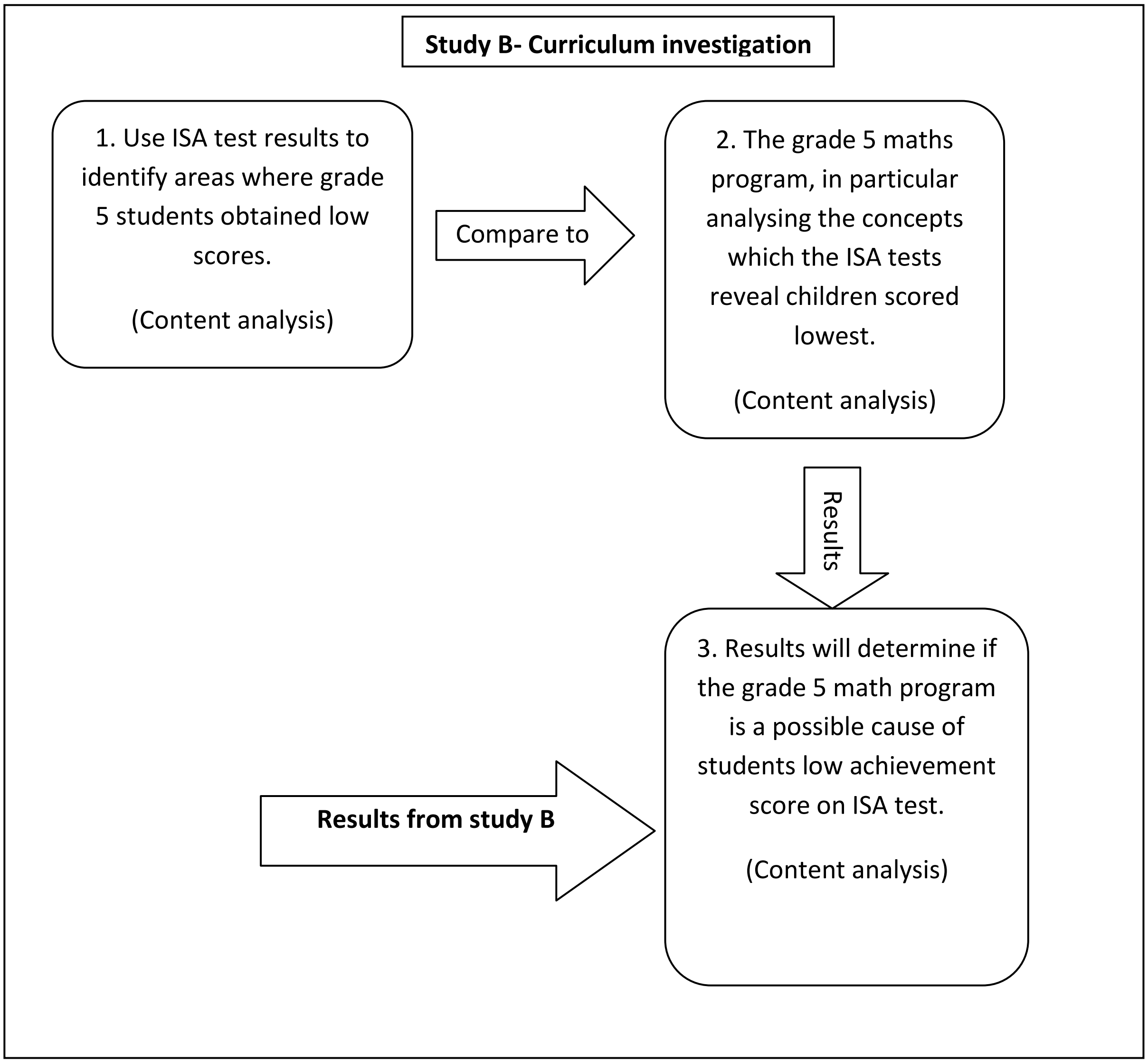

Figure 4 Analysing the grade 5 Heinemann New Math scheme

4.2.3 Study C: Methodology Investigation

Once the reliability and validity of the KHDA and teacher questionnaire is compared and contrasted and the grade 5 ISA test results and mathematics program are analysed, the third aim of this report is to gather insight in establishing whether students' low test results can be attributed to the teaching methodologies. The results will be tabulated.

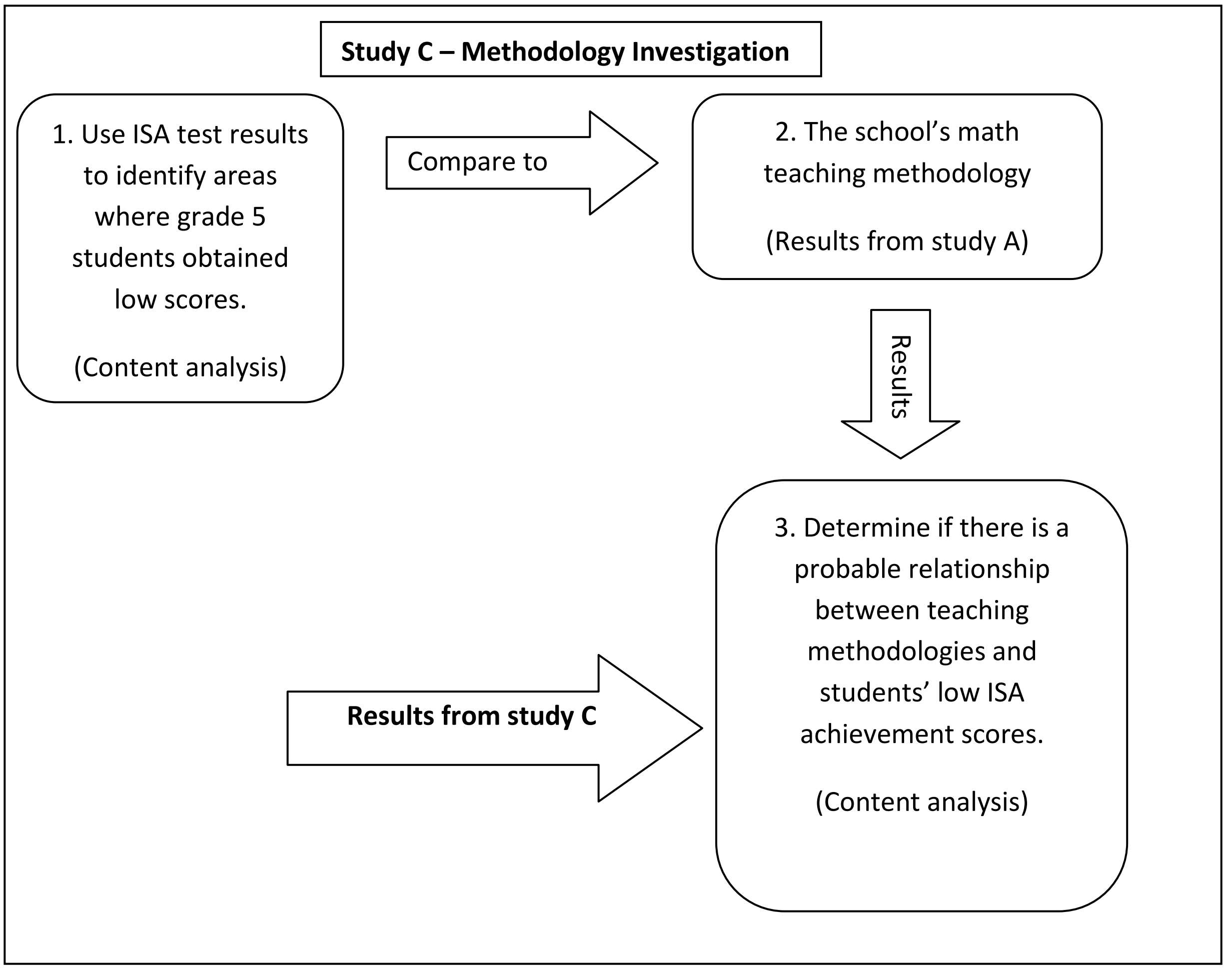

Figure 5 Identify a correlation between teaching methodologies and students' low ICA scores

4.2.4 Study D: Implementation of a New Curriculum

Due to the results of the KHDA inspection and the low student scores on the ISA test, the researcher was asked to investigate and implement a new mathematic curriculum in order to met the requirements of KHDA and improve the standard of teaching and learning. The following K-6 mathematical curriculum documents were comparatively analysed:

- Primary Years Program, maths scope and sequence
- Victorian Essential Learning Standards, Early Years program
- Singapore Mathematics Primary Syllabus,
- Mathematics in the New Zealand Curriculum
- Abu Dhabi Educational Council's K-5 Mathematis and Science Curriculum
- The national mathematics curriculum for England
- Commonwealth of Virginia, Mathematics Standards of Learning Curriculum Framework (VSOL).

The Virginian Mathematics Standards of Learning was chosen to be the most suitable curriculum document for the private international school in Dubai.

The following criteria lead to the VSOL document:

- clear and comprehendible objectives
- accessible supporting documents/resources for teachers
- encouraged a variety of teaching methodologies
- promoted use of concrete aids
- suggested activities that allow children to experience and explore mathematical concepts
- provided guidance to teachers as they plan instructional programs appropriate for their students

- identified essential mathematical understandings by defining essential content knowledge, and describing the intellectual skills students need to use.

Copyright permission was requested from the US Department of Education in Virginia, and once this was granted the school was able to incorporate the Virginian mathematic teaching and learning standards.

The researcher conducted group and individual meetings aimed to introduce the Virginian mathematic curriculum and provide the opportunity for teachers to express their thoughts and feelings, which will also reveal their pedagogical belief about mathematics. The individual and group meetings determined the extent to which mathematics reform emphasise teachers' beliefs and methodologies and provided insight into their reasons of resistance. Teachers' behaviors will be analysed according to Dalin (1978) and Dalin et al (1993) four core barriers to change: value, power, psychological and practical barriers, and Fullan's (2001) framework of leadership.

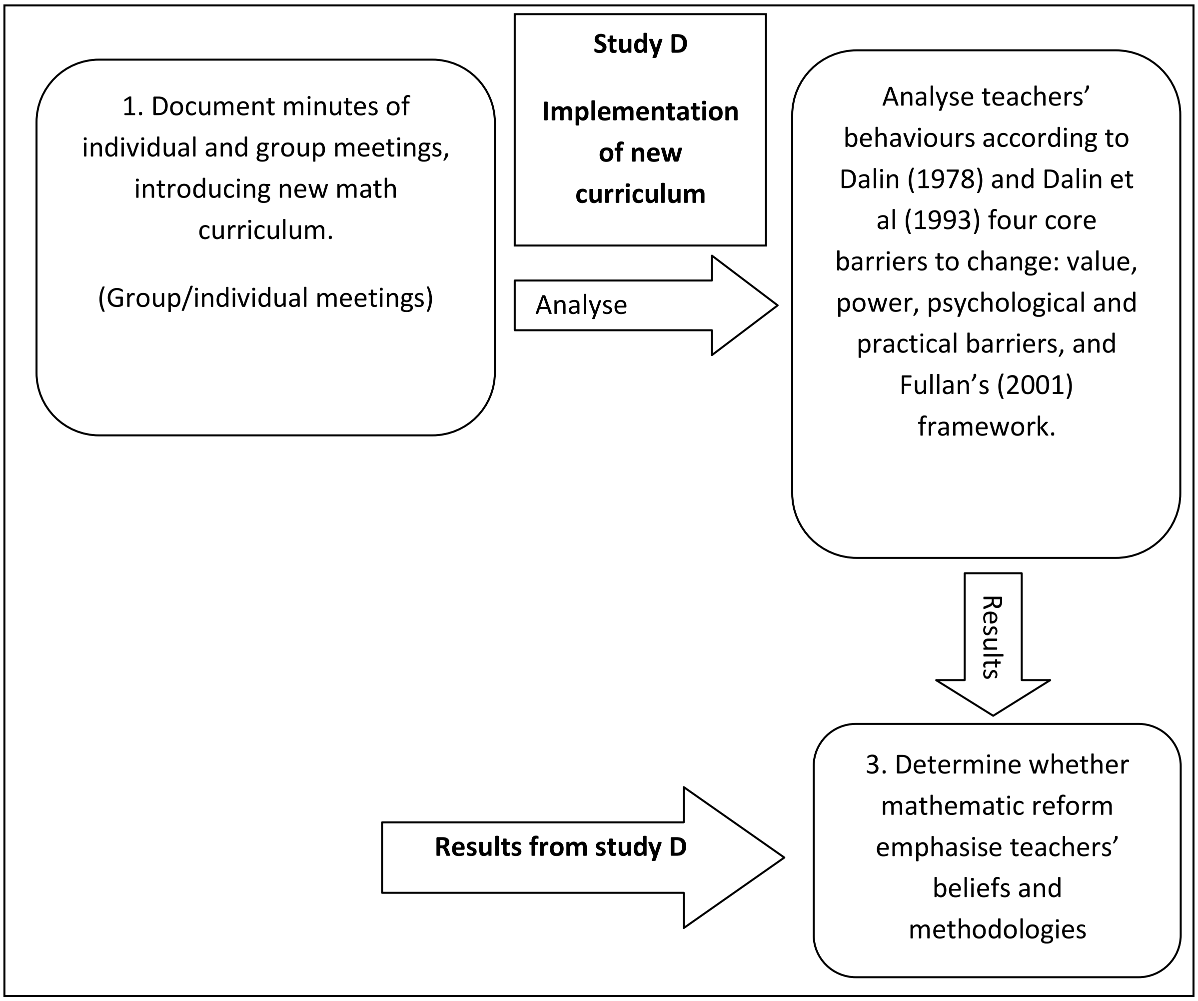

Figure 6 Analysis of maths meetings during curriculum reform using Fullan's theory

4.3 Development of the Survey

In order to gather data for Study A, a survey/questionnaire was designed to investigate K-6 teaching methods of mathematics teachers. It also intended to determine whether the KHDA inspection report was reliable. The questionnaire methodology was identified as the most effective means of gathering information due to time constraints, the large number of expected recipient responses and large amount of data which needed to be analysed.

Design of Teacher Survey/Questionnaire

The questionnaire was designed to provide data on K–6 teachers' 'mathematical-instructional' practices. Some of the questions in the survey were adapted from the Council of Chief State School Officers' (CCSSO) 'Surveys of Enacted Curriculum'. The statistical analysis adapted for this research was intended to investigate the current mathematical practices and the teachers' professional approach at the school.

The basic requirements in filling out the questionnaire involved the teachers answering close-ended questions on the percentage of time a student would spend engaged in a particular activity during the course of the year. Teachers were also required to rate their methods on the important principles of planning mathematical lessons and their belief in the role of assessment. Table 3 shows the breakdown of the 0 to 4 time rating scale.

AMOUNT OF TIME (for the school year)

0 - None

1 - Little *(10% or less of time for the school year)*

2 - Some *(11–25% of time for the school year)*

3 - Moderate *(26–50% of time for the school year)*

4 - Considerable *(50% or more of time for the school year)*

Table 3 0–4 time rating scale

The survey comprises 50 questions (Appendix Three). Careful consideration was given to ensuring that the wording was concise and avoided double questions and questions that involved negatives. These questions were divided into various sections that correlated with the aims of this study:

1. **Teaching experience**. The provided background knowledge on the number of curriculum reforms the respondent has experienced, this collected information will assist when implementing the new maths curriculum.

2. **Student activity during instructional time.** The aim of this section is to determine respondents' pedagogical approach to teaching and learning.

3. **Students actively engaged in learning.** This part of the survey aims to establish the number of school resources used. It also relates to participants' (teachers) professional approach to teaching and learning.

4. **Assessment process.** These questions intended to identify the range of summative and formative assessment practiced.

5. **Planning lessons.** Teachers are required to identify the crucial principals of a curriculum document which will enable them to guide maths lessons.

6. **Role of assessment.** The aim of this section was to establish the degree to which teachers used the assessment and adapted it to their teaching methods and catered for the diverse requirements within the grade level.

Sections 2 and 3 intend on establishing respondents' pedagogical approach to mathematics teaching and learning. The categories below will be analysed:

a) Didactic teaching

b) Constructivist learning

c) Discovery learning

d) Technology

e) Differentiation

f) Use of concrete aids for understanding concepts

Table 4 indicates the intended aim of each question within the survey.

Question	**Information Desired**
Question One **How many years of teaching experience do you have?**	Teaching experience and number of curriculum reforms experienced
Question Two **How much of the total mathematics instructional time do students:**	
2.1 Watch the teacher demonstrate how to do a procedure or solve a problem	Degree of didactic teaching
2.2 Take notes from lessons or the textbook	Degree of didactic teaching
2.3 Complete *computational exercises or procedures* from a textbook or a worksheet	Degree of teacher-centred, didactic teaching
2.4 Present or demonstrates solutions to a maths problem to the whole class	Degree of instructional and guided learning
2.5 Use manipulatives (for example,	Degree of hands-on, inquiry-based

geometric shapes or algebraic tiles), measurement instruments (for example, rulers or protractors) and data collection devices (for example, surveys or probes)	teaching
2.6 Work *in pairs or small groups* on maths exercises, problems, investigations or tasks	Degree of inquiry-based learning, differentiation
2.7 Do a mathematics activity with the class outside the classroom	Degree of inquiry-based learning, unguided
2.8 Use computers, calculators or other technology to learn mathematics	Degree of technology use
2.9 Take a quiz or test	Degree of summative assessment
2.10 Solve *word problems* individually from a textbook or worksheet	Degree of critical thinking, unguided instruction
2.11 How often do children work in differentiated groups?	Degree of teaching to point of need
Question Three **When students use *hands-on materials,* how much time do they spend:**	
3.1 Measuring objects using tools such as rulers	Degree of inquiry-based learning, actively engaged
3.2. Measuring objects using tools	Degree of inquiry-based learning,

such as scales	actively engaged
3.3 Building models or charts	Degree of inquiry-based learning, actively engaged
3.4 Collecting data by conducting surveys	Degree of inquiry-based learning, actively engaged
3.5 Presenting information to others using manipulatives (for example, chalkboard, whiteboard, posterboard, projector)	Degree of inquiry-based learning, actively engaged
Question Four **How often do you use each of the following when assessing students in mathematics class:**	
4.1 Objective items (for example, multiple choice, true/false)	Lowest order of cognitive processing
4.2 Short-answer questions such as performing a mathematical procedure	Medium order of cognitive processing
4.3 Extended response items for which students must explain or justify their solution	Highest order of cognitive processing
4.4 Performance tasks or events (for example, hands-on activities)	Degree of formative assessment
4.5 Individual or group demonstration or presentation	Degree of peer group, cooperative learning

4.6 Mathematics projects	'Real life' relevance
4.7 Systematic observation of students	Degree of summative assessment
Question Five **Please indicate the importance of the following elements when planning:**	
5.1 Making connections to real-life experiences, 'tuning in'	Information will be used to develop planning templates
5.2 Differentiated groups	Information will be used to develop planning templates
5.3 Critical thinking	Information will be used to develop planning templates
5.4Assessment (formative/summative)	Information will be used to develop planning templates
5.5 Extension activities	Information will be used to develop planning templates
5.6 Technology (MIMIO etc)	Information will be used to develop planning templates
5.7 Resources	Information will be used to develop planning templates
5.8 Follow-up home activities	Information will be used to develop planning templates

5.9 Heinemann resources	Information will be used to develop planning templates
5.10 Vocabulary	Information will be used to develop planning templates
5.11 Teacher instruction	Information will be used to develop planning templates
5.12 Student activity	Information will be used to develop planning templates
5.13 Type of learning style	Information will be used to develop planning templates
5.14 Type of teaching style	Information will be used to develop planning templates
5.15 Timing of lesson/number of lessons	Information will be used to develop planning templates
5.16 Key ideas	Information will be used to develop planning templates
Question Six **Please indicate the role of current assessment:**	
6.1. How often do you use assessment to inform your teaching?	Degree of teaching to point of need, ZPD, scaffolding
6.2. Do the assessment results provide diagnostic evidence for future	Degree of identifying children's growth points

learning?	
6.3. Do you use assessment results to accurately establish differentiation within the classroom?	Degree of targeted grouping
6.4. How often do you use formative assessment?	Degree of observation, feedback, etc.
6.5. How often do you use summative assessment?	Frequency of tests, exams, grades, etc.

Table 4 Teacher survey questions and their intended purpose

4.4 Pilot Study of the Survey

A pilot study was conducted in order to assess the reliability of the test. Bell (2005) states that any methodology of gathering data should be critically investigated, thus ensuring results are consistent under constant conditions. It was not an appropriate point in time (as it was December) to administer a pilot study to a large number of recipients because teachers were busy writing student reports. In this case, the deputy principal and a grade three teacher volunteered to partake in the pilot study. Their feedback included shortening the length of the survey (originally there were 100 questions) and rewording a number of questions to ensure that the respondents had more clarity to the information, avoiding misinterpretation. The process of discussing the survey with colleagues enabled the researcher to assess the reports validity. Once corrections were made from the initial feedback, the wording of the questionnaire was checked again; this further ascertained that each question was accurately measuring the intended purpose.

4.5 Data Collection of the Survey

Participation in the study was requested at staff meetings prior to the administration of the survey. All 42 staff members agreed to contribute and expressed an understanding of its value and purpose within the school.

Questions were typed into a computer program called Snap, a web-based program that allowed the researcher to email the questionnaire to the participants. This program was specifically chosen because it enabled the researcher to analyse the data more readily. Needless to say, data gathered quickly can be effectively and efficiently displayed in charts or pie graphs for further analysis. Another advantage of Snap is that it ensured the confidentiality and privacy of the respondents. The email containing the questionnaire clearly informed respondents that information obtained would be presented in a manner that would not reveal their identity in any way. The intention of the questionnaire was explained, and the researcher's contact details (email address) were supplied, enabling respondents to receive the results of the research in which they participated.

4.5.1 Limitations of Close-ended Questionnaires

Inaccurate data can be the drawback of 'closed-ended' questions, thus creating some limitations. Dornyai (2003), states that this may be due to unmotivated respondents who leave out or misinterpret questions. Teachers may not answer truthfully about themselves or may answer questions the way they *think* they should, rather than according to what they actually feel, believe or do. In order to avoid this, the researcher ensured that identity of individual subjects questionnaires were submitted anonymously. Participants could also deviate from the truth because they are delusional about themselves, hesitant, and fearful and hence accurate self-descriptions can become distorted. People may be unwilling to give negative responses; Dornyai (2003) terms this 'acquiescence', where participants just go along with what sounds good. Furthermore, Dornyai (2003) states that the halo effect might vary results; that is, the teacher may overgeneralise about the current mathematics program because of their reluctance or eagerness to change. There is also the phenomenon called the ‘ballot effect’, suggested by Bell (1999), whereby simply asking a question makes the respondent feel compelled to answer it, even though it may not be significant. This could result in overestimations about the importance of answers present and underestimations about the importance of answers absent. In order to avoid the ‘ballot effect’ participants can be given the option to only answer questions that they feel are important.

4.6 Document Analysis

The aim of Study B and C is to achieve an understanding of why children scored low on their ICA tests. The children’s ISA tests were compared and analysed against the results from Study A (teaching methodologies) and the Grade 5 Heinemann New Math Scheme.

4.7 Group and Individual Meetings

The purpose of this study is to attain a deeper insight into the teachers’ pedagogical beliefs about mathematics through analysing their behaviors from individual and group meetings. Teachers’ behaviors will be analysed according to Dalin (1978) and Dalin et al (1993) four core barriers to change: value, power, psychological and practical barriers, and Fullan’s (2001) framework of leadership.

The meetings were conducted in six sessions, as shown in Appendix Two. The number of sessions was not predetermined; it was highly dependent on the time available. Initially the meetings were only scheduled for the K-6 mathematics year level coordinators, which comprised of 7 subjects, however as the issues escalated it became necessary to also include the K-6 year level coordinators.

An agenda was set by the researcher for each meeting. A different recipient from every meeting voluntarily recorded the minutes. These minutes were read aloud at the conclusion of each meeting; the researcher also added dialogue and observed behaviors. These were verified by one of the participants. At the beginning of each meeting the researcher requested consent from each teacher to record their responses, thus ensuring confidentiality. Also, in order to eliminate potential bias of observed behaviors, the researcher and another member of the meeting separately identified the observed core barriers then compared notes, thus ensuring reliability of results.

The intention of the meetings was for members to interact with each other and share their views and concerns about the new math curriculum. Laws (2003) states that group and individual meetings are a valuable means of gathering in-depth information about what people think about an issue, why they hold such views and how they feel about them. This information is not possible to gather through a questionnaire or document analysis.

4.7.1 The Aims of the Group Meetings

<u>Session One</u> Group meeting with math year level coordinators.	1. To convince members that the Virginian mathematical objectives would be the most suitable document to adapt to our educational setting. This will be achieved through providing staff with a comparative analysis between the New English Curriculum and Virginian math objectives. These were selected from the kinder and grade 4 curriculum documents. The task at hand was for all members to

	choose the objectives which they felt would best assist them to plan lessons and assess students' achievements. 2. To provide each year level coordinator with a list of mathematical objectives, specific to their year level.
<u>Session Two</u> One to one meeting with a math year level coordinator.	1. Discussion about the importance of adopting the Virginian curriculum document.
<u>Session Three</u> One to one meeting with a year level coordinator.	1. Comparative analysis between objectives of old maths scheme and the Virginian document, develop an agreed set of standards for children in a primary year level.
<u>Session Four</u> Group meeting with year level coordinators, principal and deputy principals.	1. Comparison of British Framework and Virginian Standards of Learning (A/B tick-a-box sheet) 2. Outline why we are making changes (data collection from survey) 3. Outline why we are adopting Virginian (bridge to British, better support documents for teachers) 4. Go through scope and sequence document to demonstrate easy layout and resources – objectives,

	indicators, topics, activities, extension, assessment all provided. (Must email grade coordinators before meeting and ask them to bring their grade copy of VSOL Scope and Sequence so we can talk to it.) 5. Hand out copy of Grade 5/3 outline to walk them through it. Bring to attention: a. Activities taken directly from curriculum document b. Links to where Heinemann and other *resources* can be used c. How language and mathematical reasoning are key to most activities d. Assessment procedure: A) portfolio samples used as formative assessment (often in-class, observation, anecdotal, discussion-based with simple outcome-based grading system) B) topic assessments are both formative and summative assessment (grading system needs to be decided on) C) End of year skills and knowledge-based

	assessment/examination as summative assessment and used for reporting to parents (keep those parents happy who like to see an end of year exam!) 6. Address any concerns that have been presented to us to date and action decided/taken: a. Language – change to metric, dirhams, etc, but also expose to other currencies as is an international school, develop language bank for each concept and topic taught – share with ESL teachers b. Informing parents – host parent information evening at start of next academic year to inform parents on how change to new curriculum will benefit their child and how they can support their child at home – 'fun with Maths' nights for parents and kids 7. Question time
<u>Session Five</u> Group meeting with grades 4-6 year level math coordinators, some	1. To guide staff through the process of developing the daily plan, using a template which incorporates new

members of their team, Junior and Primary school math coordinators and Junior school deputy principal.	teaching methodologies (small group focus, using concrete aids, etc) 2. Explain organisation of daily math lessons i.e. whole\part\whole
<u>Session Six</u> Group meeting with K-3 year level math coordinators, some members of their team, Junior and Primary school math coordinators and Primary school deputy principal.	1. To guide staff through the process of developing the daily plan, using a template which incorporates new teaching methodologies (small group focus, using concrete aids, etc) 2. Explain organisation of daily math lessons i.e. whole\part\whole.

4.7.2 Limitations of Individual and Focus Group Meetings

Conducting and analysing the group and individual meetings was time consuming. Unlike individual meetings, the group meetings were not confidential; therefore the group dynamics may have inhibited some members from contributing their views, thoughts and feelings, while assisting others.

Chapter 5. Analysis of Findings

5.1 Study A: Results from Survey

The survey for Study A was designed to identify the current teaching methodologies. Strategic planning and consideration was given to the development of the survey, enabling the researcher to analyse data and categorise main teaching pedagogies: didactic teaching, constructivist teaching, discovery learning, incorporating technology, differentiated learning, use of concrete aids for understanding mathematical concepts and their use of assessment.

Once the responses were categorised they were entered into an Excel spreadsheet and were computed into percentages, for ease of comparison, then reverted to its original score (based on the Likert Scale) and presented in the representative columns.

The survey measured respondents' perceptions in five areas on the Likert Scale. This categorises responses as:

AMOUNT OF TIME *(for the school year)*

0 - None

1 - Little *(10% or less of time for the school year)*

2 - Some *(11–25% of time for the school year)*

3 - Moderate *(26–50% of time for the school year)*

4 - Considerable *(50% or more of time for the school year)*

A total number of 27 responses were received which reflects a 64% response rate. In a total of 42 mathematics teachers, 3 teachers were male; therefore in order to ensure confidentiality of these staff members the gender of each recipient was not required.

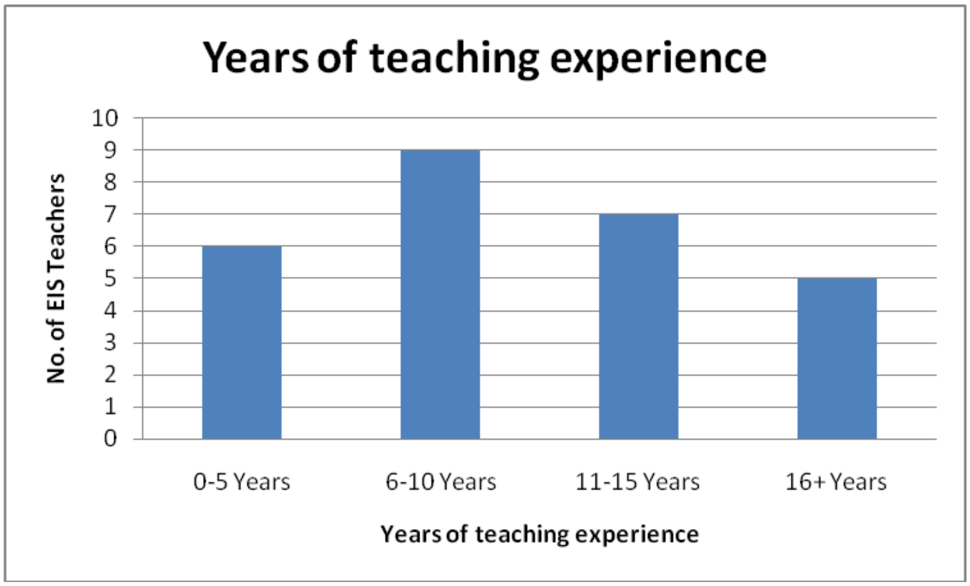

Figure 7 Teachers' years of teaching experience

Figure 7 shows that the average number of teaching experience is 6.75 years. This indicates that a majority of staff members would have been exposed to an education system that was potentially influenced by Vygotsky because he contributed to the third era of a major educational reform. From the period of 1978 to the present, the 'human constructivist' era places an importance on social and conceptual learning. Therefore it is assumed this 'human constructivist' methodology was taught as part of teachers bachelor degrees or educational diplomas.

Research suggests that teachers teach mathematics the way that they were taught in schools; thus approximately 55% of recipients in this study should be adopting a 'human constructivist' approach to teaching and learning. This is in line with what is reflected in the school goals, but it contradicts the findings of the KHDA inspection report, which suggests that teachers use didactic methodologies.

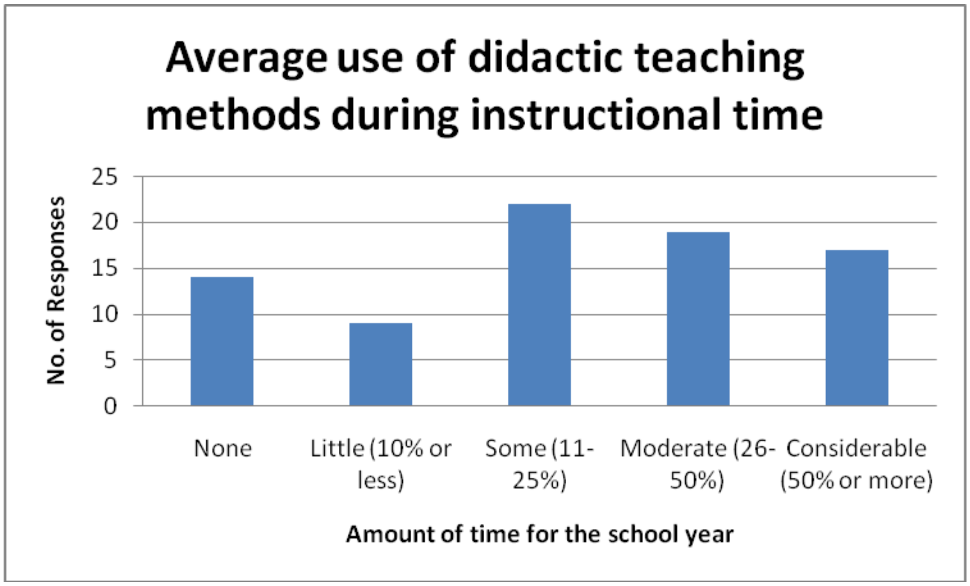

Figure 8 The average use of didactic teaching methods during instructional time

These results were accumulated from teachers' responses to questions 2, 2.1 and 2.2. Evidently the results of figure 8 show that 'some', 'moderate' and 'considerable' were the main responses. The majority (27%) of staff members declared that they used 'some' didactic teaching methodologies during instructional time. According to the Likert scale, that represents 11-25% of time throughout the academic year. 24% of recipients stated that they used didactic teaching methodologies 'moderately', which indicates 26-50% of time within the school year, and 21% of individuals confirmed that they employed didactic methodologies 'considerably', which equates to more than 50% of their teaching time.

Therefore these results suggest that the majority of teachers employ a didactic teaching methodology within their classroom practice. These findings support the results of the KHDA inspection report. However they do not support the goals of the school, which state that children are encouraged to develop their *critical thinking* and *problem solving* skills. Evidently, research shows that didactic teaching is a traditional method which places children as passive receptors of knowledge, as supported by Sfard (1998) and does not engage children in the learning. The nature of developing *critical thinking* and *problem solving* skills within children is not possible though a didactic method of teaching.

However, research found by Woodheads (2001) indicates that the didactic methodology can be beneficial if applied by a skillful teacher. One means of measuring if the teachers applied the didactic method in the above skillful manner would be via grade 5 students' scores on their ISA test. Evidently, the children's mathematical literacy scores were low, which indicate that within the school the didactic methodology is an inefficient method of teaching children mathematics, and hence supports the findings of Stipek, Feiler, Daniels and Milburn (1995) who found that children taught in the didactic method achieved less and were less motivated when compared to the children taught in child-centered programs. Furthermore, these findings of didactic teaching and their relationship between children's low ISA results is supported by Katz (1998 cited in Stipek et al 1995) research which indicates that didactic instruction inhibits intellectual ability directly through fostering superficial learning of simple responses rather than real understanding and problem solving.

These results do not support the research which suggests that teachers resort to teaching in the way that they themselves were taught, especially since the average number of teaching years is only 6.75, thus indicating that members would have been too young to have been taught during the

‘Practicalist’, (1918-1957) or ‘Academist’ (1958-1977) era. Rather it supports Battista’s (1994) explanation whereby if teachers lack content knowledge and understanding then they will resort to teaching mathematics as a set of facts and procedures to be transmitted.

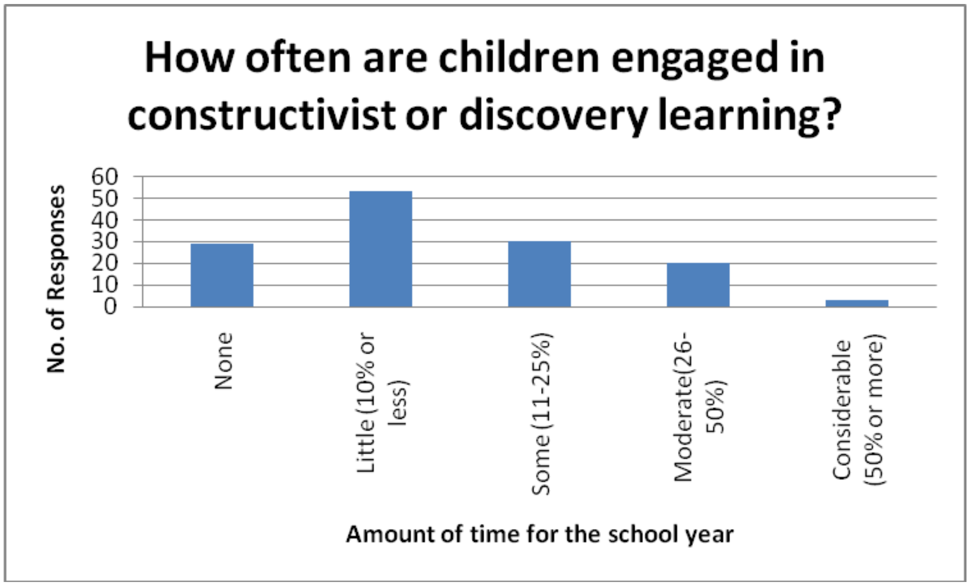

Figure 9 Amount of time children are engaged in constructivist or discovery learning

These results were compiled from teacher’s responses to question 3, 3.1, 3.2, 3.3, and 3.4 of the survey; all of which indicate their use in employing a constructivist or discovery learning methodology. Figure 9 clearly indicates that only 2% of teachers engage students in constructivist or discovery learning 50% or more of the time during mathematics lessons for the entire school year.

Here the results support the view that teachers at the school predominantly adopt a didactic approach to teaching mathematics. They also support the findings of the KHDA report. Evidently, research conducted by Kirschner, Sweller and Clark (2006) do not support pure constructive or discovery learning and favor the benefits of a guided constructivist approach. Nonetheless, the results from the survey do not indicate that either methodology is sufficiently applied.

Furthermore, the grade 5 students' low achievement scores on their ISA tests is another indication that a didactic teaching approach is an ineffective methodology. Consequently, Raizen's (1996, cited in Garet, Birman, Porter, Desimore and Herman 1998), states that children learn best when they are active participants, engaging in activities rather than recipients of lecture-style instruction.

On the contrary Hattie (2008) used 800 meta studies which collectively look at 83 million students and found the following effect sizes:

Problem based teaching = 0.15
Inquiry based teaching = 0.31
Direct instruction = 0.59

However, direct instruction is not the same as didactic teaching. Direct instruction is when the teacher has a clear idea of what the learning objectives are and has clear aims for each lesson, which are stated explicitly to students thus ensuring that they know what is expected of them. Teachers also 'hook' children into the learning, i.e. put them into the right frame of mind through a variety of means such as videos, pictures, lectures, tapes etc. This modeling is to ensure that children have a clear understanding of what they are expected to do before they proceed. It is crucial that the teacher checks for student understanding ensuring that have the necessary knowledge before completing the task independently. If the child does not have a clear understanding of what to do then the teacher must demonstrate the process again. Following the instructional session, the teacher then goes on to perform guided practice, which involves giving the child the opportunity to practice the knowledge, and under the teacher's direct supervision, the students are given instant feedback about the progress they are making. At the conclusion of the lesson the teacher ensures that the children have closure; this means that the learning objectives are identified and children have the opportunity to form a coherent picture, eliminate confusion, consolidate and clarify the key learning points.

The major issue with didactic teaching is that it fails to engage children in the learning process, meaning the teacher does not ‘hook’ the students in to the learning.

Due to the dual nature of mathematics, Tanner and Jones (2000) stated that it is a body of knowledge consisting of facts and rules to be memorised and a construction of knowledge for making sense of the world, emphasising creativity, investigation and problem solving. The current questionnaire results highlight that the pendulum swings closer towards a didactic teaching and direct instruction approach, rather than a guided-constructivist or constructivist.

Based on the children’s ISA scores, evidence suggests that teachers are not employing a direct instruction approach because Hatties extensive research has proven the benefits on student achievement. This further proves that a didactic pedagogy in teaching mathematics is ineffective and teachers are required to develop their pedagogical knowledge of effective teaching and learning practices.

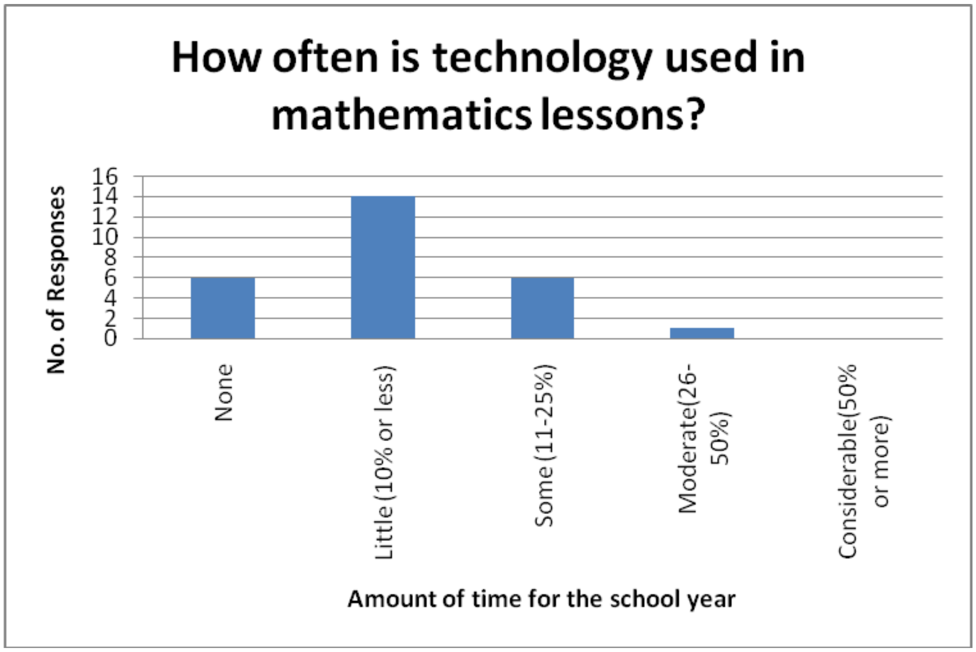

Figure 10 Amount of time teachers use technology in mathematics lessons

The results reveal that 22% of teachers did not incorporate any technology into their mathematics lessons. Only 4% of staff members claimed they used technology ‘moderately’.

These results support Clements et al (1993) study that teachers use technology to reinforce traditional methods rather than using it as an innovative method supporting collaborate, student-centered environments. 22% of teachers at the school do not incorporate technology during mathematics lessons; this finding is discouraging but not surprising. On balance, this finding is somewhat at variance with the results of Bracy’s (1988) study, in which he suggests that an effective amalgamation of ICT in the classroom only occurs in settings where teachers and learners engage in collaborative and problem solving environments.

Evidently the teachers (4%) who stated using technology ‘moderately’ in the classroom may have had little or an adverse impact on children, because, as stated by Callister et al (1992) if computers are used to import and amplify poor pedagogy (didactic, traditional-style of teaching) then they can hinder learning.

On the contrary, the little use or absence of incorporating ICT within a didactic teaching setting (which has been demonstrated to be the predominate methodology at the school) should not have contributed to students' low ISA scores because there is much research which suggests it is only beneficial to children's learning if it is incorporated in a collaborative classroom setting (Schofield, Eurich-Fulcer, Britt 1994; Becker 1993; Kulik and Kulik 1991; Swan and Mitrani 1993; Mayer, Schustack and Blanton 1999).

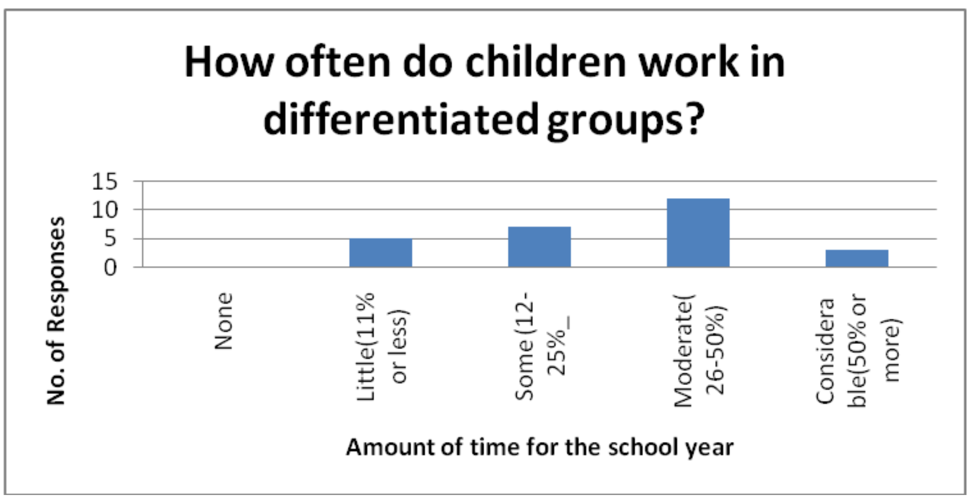

Figure 11 How often do children work in differentiated groups?

Evidently, all teachers reported using differentiated grouping to some degree within their mathematics lessons. However, this result contradicts all the evidence that has been pointing towards the didactic teaching methodology thus far.

Upon analysis the researcher discovered that this result may be due to the structure of the mathematics program in levels 4, 5 and 6, where children are streamed into classes according to their ability level. The 4, 5 and 6 teachers were approached and questioned whether they believed their 'streaming' program was equivalent to differentiated grouping. The majority agreed therefore these scores do not entirely reflect the true nature of using differentiated groups within a mixed-ability classroom. Furthermore, the true nature of differentiated grouping is based on a constructivist, child-centered methodology, which stems from Vygotsky's (1970, cited in Slavin 2006) 'zone of proximal development' and 'scaffolding' theory. Using differentiation within the classroom assists children to become better problem solvers and independent thinkers as they work in small groups exploring the mathematical concept set by the classroom teacher. If this methodology was applied correctly then children should have achieved higher results, as documented in their ISA report.

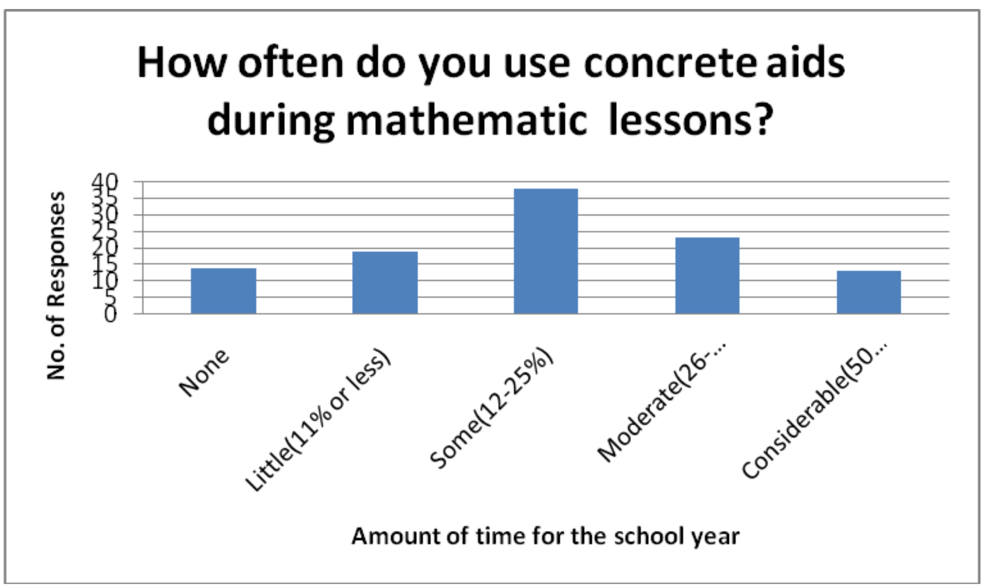

Figure 12 Amount of time teachers use concrete aids during mathematics lessons

Clearly, Figure 12 illustrates that 36% of teachers incorporate concrete aids during their mathematics lessons. Interestingly, 13% of teachers claim they do not use any concrete aids during mathematics lessons. This supports the findings that a didactic teaching approach is predominately applied by teachers at the school. Studies conducted by Ojose (2008) demonstrate that as students use the concrete materials they acquire the experience which lays the foundation for more advanced mathematical thinking, and this enhances the mathematical development of children. Consequently, children may have obtained low scores on their ISA tests because they do not have a solid foundation with which to build mathematical thinking.

5.2 Study B: Results of Curriculum Investigation

Upon investigation of students' low ISA test scores and the grade 5 math program, a new, discouraging and unexpected discovery was made. All grade 5 teachers claimed to follow the grade 5 New Heinemann Mathematic scheme, however through their explanations it became clear that many units of work were not covered. They claimed that this was typically due to two reasons: time constraints and reporting.

Firstly, demands which shortened teaching time included productions, camps, international day, book week, holidays etc. Therefore teachers felt as though they either had to rush through teaching units of work or skip them all together.

Secondly, teachers were instructed by their year level math coordinator that children had to complete the assessment booklet (also known as the 'check-up' assessment book) then record individual student scores in their mark books; at the end of the semester teachers were required to add the total in order to establish a score. This summative assessment score was used to determine the child's mark (1-7). Below is the breakdown of the scoring scale:

7 = 90-100%

6 = 80-90%

5 = 70-80%

4 = 60-70% (pass)

3 = 50-40% (Pass)

2 = 30-20% (fail)

1= 20%-0 (fail)

This mark was recorded on children's individual end of semester report. Evidently, because this was the only method used to report to parents about their child's mathematic ability and progress, teachers felt accountable for these scores and parents became fixated on them, putting pressure on teachers and students to produce a reporting grade of 7. Therefore teachers focused their lessons on the units which required the content knowledge and completion of the 'check-up' assessment pages. The grade 5 math program given to the researcher clearly highlighted that the units which were covered were accompanied by a 'check-up' assessment and the units not covered did not refer to the 'check-up' assessment.

The tabulated list identifies the mathematical concepts the grade 5 students scored lower in comparison to 'other like schools' and 'all other schools' on their ISA test and a list of mathematics units which were not covered within the grade 5 program.

List of mathematical concepts students scored *lowest* in their ISA tests	**List of mathematical concepts *not* covered in Grade 5**
Money	(Unit 11) Money and real life problems
Problem solving	(Unit 11) Making decisions and checking results, including using a calculator
	(Unit 8) Measures, including problems
Shape	(Unit 5) Shape and space, reasoning about shapes
Interpreting Graphs	(Unit 12) Properties of numbers, reasoning about numbers
Area	(Unit 3) Mental calculation strategies (x) (/)
Adaptation	
Interpreting Tables	(Unit 7) Handling data using a calculator
Scale	(Unit 4) Fractions, decimals and percentages ratio and proportion
Proportions	
Number Pattern	(Unit 1) Place value, ordering and

Line graph	rounding using a calculator

Table 5 Grade 5 ISA concepts children scored lowest in and math concepts not covered

These findings are significant. They show that there is a direct match between the areas in which the grade 5 students scored low and the units that were ‘skipped’ within the grade 5 program. The results highlight that children who answered incorrectly on questions pertaining to money did so because they had not been taught the unit of work on money and its application to real life situations. Also, children who had difficulty with understanding the problem solving questions had not covered the unit on making decisions, checking results, using a calculator and understanding measures which include solving problems. Based on the results it can be stated that children scored low on shape questions because they had not been taught the unit on shape and space and reasoning about shapes. Student’s low scores on area and adaptation are indicative to not being exposed to lessons containing mental calculation strategies. The data shows that children had difficulty interpreting graphs and tables, due to their insufficient knowledge on properties of numbers, reasoning about numbers and handling data using a calculator. Furthermore, not teaching children fractions, decimals, percentages, ratio and proportions, place value, ordering and rounding using a calculator effected their ability to accurately answer questions that related to scale, proportions, number patterns and line graphs.

These results insinuate that the students’ low achievement scores could also be due to a poorly structured and implemented program because there was insufficient cover of mathematical concepts.

However, 18.4% of students scored equal to the mean of 'all like schools': there was no evidence which suggested that any student from grade 5 scored equal to 'all other schools'. The researcher investigated the inverse, which involved extracting the areas that these children scored higher than their own mean and analysed it against the grade 5 program in order to determine if the concepts were taught.

List of mathematical concepts students scored *higher* in their ISA tests	**List of mathematical concepts *covered* in Grade 5**
Count the number of cubes used in a geometric model. Select the correct plan of a given 3-dimensional view. Draw a shape with specified area on a grid. Recognise a 3-D model given its faces	Shape and Space, reasoning about shapes and measurement including problems (Unit 8-10)
Continue a simple addition pattern to find a value later in the pattern. Extend a simple addition pattern to find the term with a particular value.	Addition and Subtraction (Unit 11)
Choose the correct method to solve a problem involving proportion. Select the correct expression to solve a problem involving proportion. Solve a problem involving proportion.	Fractions (Unit 5)

Solve a problem requiring correct conversion of units.	Weight (part of Unit 7-8)
Select a 5-digit number given its value in words.	Decimals and Percentages (Unit 5)
Read a value from a line graph	N/A
Interpret 'below' to locate a position on a given diagram.	N/A
Identify information in a table	N/A

Table 6 Grade 5 ISA concepts children scored higher in and math concepts covered

The results show that the majority of the concepts in which children scored higher were taught within planned mathematic lessons. This evidence strengthens the notion that children received low scores on their ISA tests because there was insufficient coverage of mathematic topics taught. However, although children scored higher in the 'taught' mathematic topics, when compared to 'all other schools' children at the school still scored below the mean.

This supports the idea that the maths program and the teaching methodology employed by the teachers is a major contributing factor to children's low ISA scores.

5.4 Study C: Results of Methodology Investigation

This investigation was carried out in order to find out whether the teachers' methodological practices contributed to the children's low ISA achievement scores. Based on the findings of the survey, it is evident that the majority of teachers adopt a didactic methodology of teaching mathematics. Technology and concrete aids are seldom used, along with any forms of a constructivist and discovery approach to learning. Statistical evidence suggests that teachers use differentiated groups within their instructional program.

Therefore, it is believed that children had difficulty in specific concepts highlighted in the ISA test because they were not exposed to teaching methodologies which encouraged such thinking. For example, many children had trouble answering questions which related to using the calculator, hence a simple reason for this would be because only 4% of staff claimed to use technology in their mathematics lessons. Furthermore, research suggests that problem solving understanding is best developed in children through using a constructivist/guided-constructivist/discovery learning approach, thus through enabling them to explore and experience mathematical concepts will inevitably enable them to build solid foundations and develop a greater capacity to comprehend problems independently. Nonetheless, this paper is not determining whether problem solving is best taught as a skill and used as a method of teaching, more so, it highlights that neither are evident in the grade 5 classroom and curriculum.

Also, 14% of teachers claimed that they did not use concrete aids to assist children with mathematical understanding – again, this may have greatly attributed to the children's inability to understand the ISA mathematical concepts displayed in table 6. In particular, research conducted by the Australian Education Council (1991) has shown that children do not develop their mathematical understanding through a simple means of transmitting knowledge; rather they learn best when taught in a method of inquiry which involves problem solving, visualisation, reasoning, experimenting, communicating and applying - especially in mathematical areas of proportions (fractions), area and shape.

5.5 Study D: Results of Implementation of a New Curriculum

The aim of this study is to achieve a greater insight into the teachers' pedagogical beliefs about mathematics through analysing their behaviors as they undergo a math curriculum reform. Teachers behaviors will be analysed according to Dalin (1978) and Dalin et al (1993) four core barriers to change: value, power, psychological and practical barriers and Fullan's (2001) framework of leadership. Through understanding individual barriers to math reform, this paper will be able to understand teaching methodologies at the school.

Motivation, Reaction to Change	**Session One** Group meeting Year level K-6 Math coordinators Observed behaviors	**Session Two** 1 to 1 meeting Math year level coordinator Observed behaviors	**Session Three** 1 to 1 meeting Year level coordinator Observed behaviors	**Session Four** Group meeting Year level K-6 coordinators Observed behaviors	**Session Five** Group meeting K-3 staff math coordinators and one other member of their team Observed behaviors	**Session Six** Group meeting K-3 staff math coordinators and one other member of their team Observed behaviors
Value barrier			X	X		
Power barrier						
Psychological barrier	X	X		X		
Practical barrier	X	X		X	X	

Table 7 The teachers' reaction to mathematics curriculum reform

The results from table 7 show that teachers' displayed resistance of 33% because of their values. There was no evidence of resistance based on power, whereby individuals felt the change would diminish or strengthen their power. Teachers displayed resistance due to psychological issues (50% of the meetings) and 66% of the defiance was due to their practical barriers.

In session one, all year level math coordinators agreed and stated that the Virginian curriculum was the '*clearest, most detailed and easiest to interpret set of objectives'.* However two staff members were very resistant to change stating '*I do not want to sound negative but why can't we just continue using the scheme we have already? Just implement it properly?'* After the primary school math coordinator explained the KHDA results and the results of teaching methodologies evident from this report, the staff members continued to defend the old teaching methodologies and expressed that they had been using the Heinemann New Math scheme for many years and felt strongly that it was a 'good' program. They also expressed that streaming children in ability classes was beneficial and stated *"How will we make sure that all students are catered for within the class?"* With this statement it became clear that these staff members were displaying psychological and practical resistance to change. Dalin (1978) and Dalin et al (1993) state that such a reaction to change stems from individuals whose confidence and emotional well being feels challenged and believe that they will be deskilled, especially if they feel as though they do not know how to cater for a mixed ability group. Fullan (2001) believes this reaction occurs when an individual's moral purpose has to change, and the stronger they express their opinions the more they will experience the feeling of being deeply disturbed throughout the changing process. During session one it was also asked *'well what will the planning document need to look like?';* within the context of the meeting this question was asked in a patronising tone. Again this provides evidence that some teachers were feeling threatened as professionals and that their judgments and performance was undervalued. Consequently, their enthusiasm, and belief that they had the skills to make changes was lost.

Fullan (2001) believes that this is a crucial stage of a curriculum reform and part of the changing process. This resistance experienced from staff members is recognised as 'an implementation dip', whereby the leaders need to recognise the staff's dilemma and take the opportunity to refine the opposing force by learning something new from those who disagree as there may be ideas missed. Fullan (2001) also believes that if such resistance is ignored then they may resort to superficial compliance, which may be a reason why there have been numerous unsuccessful mathematics reforms.

Session two was a one-to-one meeting between the researcher and the main year level math coordinator who expressed strong resistance in session one. During this meeting it became apparent that emotions were stemming from technical knowhow and the lack of knowledge and confidence to implement the new curriculum and teaching methodologies.

Session three was another one-to-one meeting with a year level coordinator, who was not present at the first meeting, but who also expressed opposition towards the new curriculum by stating that, *"the proposed objectives were too easy for the children in her year level"*. This gives evidence of defiant beliefs in her fundamental values. Therefore and most importantly, the initiative of the one-to-one meeting is to listen, acknowledge, remain in tune and *validate* the teachers' concerns; this process of working together will overcome the issues raised, and change accepted with greater ease and cooperation. Fullan (2001) states that this resistance is okay because it is a part of transforming the culture through 'collaborate building' of knowledge and relationships, thus enabling the school to become coherent and creating a culture of change.

During session four, staff members displayed evidence of value, psychological and practical barriers. Maurer (1996) states that often those who resist have something important to tell us. This became particularly evident when one teacher stated, *'this (Virginian) document is too easy for the children and in the past when the school had a math reform and made the change from the British curriculum to American curriculum some children missed out on learning certain mathematical concepts and hence my daughter was one of those children who suffered as a result of it.'* As suggested by Clarke (1994) some staff members' resistance relates to being personally connected to unsuccessful results of prior experiences, hence these staff members may require psychological support through validation of their objectives. However, following this comment, another staff member stated *'I have had a meeting with the math coordinator and we were able to negotiate on the math objectives and make some changes which will best suit the needs of the children in this setting… I feel much more comfortable with implementing the standards now'* Fullan (2001) describes this change in behavior as the individual feeling mobilised and having a sense of purpose and direction, thus enthused to make a difference and become part of the success story. This is also evidence that through a process of developing relationships, knowledge building and coherence making, individuals can begin to develop intrinsic motivation.

In session five some staff members clearly displayed 'practical' resistance by not completing the task required of them and justifying their action by stating, *'I was not asked to be in this position, I was just told that I had to be a math year level coordinator (four years ago)… this it too much work… I do not have the time…'* In using Fullan's (2001) approach to leadership it makes it difficult for members to make superficial compliance because their lack of contribution is noticed. This individual's lack of contribution was noticed and their resistance had become apparent. There was no recorded opposition in session six. Fullan (2001) states that disturbing the equilibrium is okay; especially if the focus is of a moral purpose, part of the change process, building of relationships and knowledge. Navigating through all this messiness will assist in working towards developing cohesion.

The meetings were a benefit to both teachers, who could express their thoughts and feelings about the changes proposed to the math curriculum, and, of course, the researcher, who gained from the process through observing the teachers' behaviours which highlighted their fundamental beliefs.

Upon analysis of individual and group meetings, it became apparent that staff resistance to the curriculum reform was mainly due to their ‘lack of technical knowhow’. This supports the survey and KHDA investigation that teachers at the school predominately use didactic teaching methodologies and inevitably they expressed resistance towards adopting a curriculum that differed to their current teaching pedagogies.

Chapter 6. Conclusions

6.1 Overall Conclusions

This research consisted of four studies:

6.1.2 Study A: To identify teachers' pedagogy and compare it to the KHDA inspection report.

Data gathered was through a teacher questionnaire. The results of the questionnaire showed that 21% of individuals *significantly* used didactic methodologies, which equates to more than 50% of their teaching time. 2% of teachers engage students in constructivist or discovery learning for 50% or more of the time during mathematics lessons during the entire school year. 22% of teachers did not incorporate any technology into their mathematics lessons. All teachers used some degree of differentiated groupings within their classes. 13% of teachers did not use any concrete aids to assist children with understanding mathematical concepts. These results showed that teachers at the school are not incorporating current or best teaching methodologies identified by past research. The findings also support the KHDA inspection report, which states that teachers need to extend their teaching to ensure high quality learning experiences for students and to develop the children's capacity for independent learning.

6.1.3 Study B and C: Curriculum and methodology investigation

The researcher used the grade 5 ISA results to ascertain whether these test scores were attributed to teaching methodologies and/or the New Heinemann Math scheme. The areas that children scored lowest in comparison to 'other like schools' and 'all other schools' were identified and analysed against the grade 5 New Heinemann Math scheme. The results revealed that children scored low in those mathematics concepts because there was insufficient coverage of objectives, whereby units of work were skipped due to time constraints and were not appropriately managed. This is not due to the New Heinemann Math program, rather, teachers disclosed that certain math units were not taught due to time constraints. Hence the only math units that were covered depended on whether there was summative assessment provided within the unit which needed to be recorded for reporting purposes. Furthermore, the results also revealed that children had difficulty in specific concepts highlighted in the ISA test because they were not exposed to teaching methodologies which encouraged constructive and logical thinking.

Due to the results of the KHDA inspection, and this report, it was necessary for the school to adopt a mathematics curriculum. The Virginian curriculum document was chosen as the most suitable for the school, simply because of the clarity in the text and, most importantly its ability to assist staff with planning and implementing lessons that does not rely on filling out pages in a text book.

6.1.4 Study D: Implementation of a new curriculum

The third aim of this report was to use group and individual meetings as a means for teachers to express their thoughts and feelings during the process of a curriculum reform, thus giving evidence of their pedagogical belief about mathematics. The major results show that 66% of resistance to curriculum reform was mainly attributed to their lack of technical knowhow. As a result, because the staff were confronted with a document that required teaching methodologies which were unfamiliar to their own didactic approach (comfort zone) they displayed behaviors of opposition. This supports the findings of didactic teaching.

6.2 Recommendations

This research highlights that the application of only one teaching methodology hinders students' achievements. Research by Battista (1994) shows that if teachers lack content knowledge and understanding then they will resort to teaching mathematics as a set of facts and procedures to be transmitted – this has proven to be the case at the school.

Based on the findings of this paper, teachers mainly use a didactic teaching methodology, therefore they need to learn new skills and develop new insights into the pedagogy and their own practice. They also need to explore and expand their understanding of the mathematics content and application through a variety of resources that will offer children a range of mathematical experiences.

Achieving this standard would include a number of activities, 'formal' and 'informal', such as in service education, individual development, peer collaboration and peer coaching or mentoring through the application of a 'critical friend'. Within the teaching profession, 'critical friends' are colleagues who work together to provide support and advice. They observe each other's lessons and give feedback. Randall with Thronton (2001) state that the very act of observing and offering advice benefits not only the one being viewed but also the one observing. Feedback is crucial if educators are to become autonomous and reflective practitioners. Fostering teacher growth in this manner will create an environment that encourages them to work cohesively together towards achieving the goals of the school which aim to:

Develop differentiated programs of learning which support first class teaching for all students and develop critical thinking, problem solving, research, independence and interdependence skills within learning programs.

Through such means in developing teachers' *content knowledge* and *challenge their existing mind-set* about the nature of mathematics, the school is working towards creating a culture of change. Changing the environment and the culture of the school is the key to successful implementation of the new mathematics curriculum. Fullan (2001) believes that placing individuals into unchanged environments is ineffective and leaders need to aim to develop new surroundings that are conducive to learning and sharing that learning.

Large schools, such as this school, would benefit from employing a curriculum coordinator. This person would be responsible for providing educational leadership within the school in an active and supportive manner. The curriculum coordinator would be responsible for assisting teachers in the planning, implementation and evaluation of units and programs, supporting classroom teachers in the development at the beginning of each unit of work, manage the overview of curriculum development, school wide and at classroom levels. They would also be required to implement good practices in all areas of the curriculum, purchase resources and be aware of the school's resource development, provide professional development for staff and parents as needs arise, continue the development of curriculum and coordinate documentation of all levels of curriculum.

6.3 Future Research

It is recommended that future research should re-evaluate the KDHA inspection report, which will be conducted in 2010, and re-examine the results of the ISA tests, also to be undertaken in February 2010. Raised student ISA scores towards the mean of 'other like schools' will reveal the impact of the Virginian math curriculum and new teaching methodologies implemented by the school. Furthermore, the scope of this research has been somewhat restricted to assessment of staff skills and students results and does not concentrate on other stakeholders such as the views and influence of the parents. The author wishes to encourage research into the crucial role of the home environment, and parents and their views on mathematics teaching, understandings and level of involvement.

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Appendix One

حكومة دبي
GOVERNMENT OF DUBAI

هيئة المعرفة والتنمية البشرية
KNOWLEDGE & HUMAN DEVELOPMENT AUTHORITY

جهاز الرقابة المدرسية في دبي
Dubai Schools Inspection Bureau

Summary of the inspection report on	Emirates International School Jumeirah
Publication Date of report	Month: April, Year: 2009
School established for	18 **years**

School type	Private	Name of Principal	[illegible]
Date of inspection	November 2008	Number of students on roll	1,813
Curriculum provided	UK/IB	Contact telephone	04 3489804

Dubai School Inspection Bureau identified:

Key strengths of the school:

- Leadership capacity within the school. Leaders were planning strategically and had created a momentum for improvement;
- The quality and sufficiency of staffing and facilities and close attention to health, safety and student welfare;
- Rich and extensive curricular and extra-curricular opportunities available to students;
- The contribution of the school to the students' personal, social and cultural education.

Dubai Schools Inspection Bureau requires that the school take the following action to secure further improvement:

- Extend best practice in teaching across the school to ensure consistently high quality learning experiences for students and to develop the capacity for independent learning;
- Improve arrangements for the assessment of students' work across the whole school and extend best practice to ensure a more consistent and effective approach to tracking students' progress;
- Implement procedures to increase the existing use of data to inform teaching and learning;
- Build and develop coherence in the curriculum by adopting agreed international standards and benchmarks;
- Review and determine the level of support so that all students proceed to the next level of their

education well prepared;

- The Board should play a more strategic role in ensuring the accountability of the school for its performance and in sustaining the momentum of school improvement through continuing high quality leadership.

Level 4: Outstanding Level 3: Good Level 2: Acceptable Level 1: Unsatisfactory	How well does the school perform overall?	**Acceptable**

Next steps:

Emirates International School Jumeirah has to prepare an action plan indicating how they will address the main findings of the report, and to share that plan with parents. This action plan will be made available to parents within six weeks of the delivery date of the report to the school. The next inspection will report on the progress made by the school.

About Inspections:

The purpose of inspection

The inspection was part of a strategy to evaluate educational standards and quality in all of the schools in Dubai. The inspection covered core aspects of the work of the school at all stages. Inspectors assessed the students' progress in key subjects, in particular, Arabic, Islamic Studies, English, mathematics and science (Grades 6 -12). They evaluated important aspects of the work of the school including the quality of teaching and learning, the arrangements to protect and support students including health and safety, leadership and management and the school's capacity for improvement.

The framework for inspection

All schools in Dubai were evaluated against seven central questions based on internationally accepted research into school effectiveness. Inspectors' evaluations concluded with a final judgement regarding the overall performance of the school. In the first cycle of inspections the judgement used for every school was:

Appendix Two

Session One

Date: 12th May 2009 *Time:* 2:40pm *Duration*: 45 minutes

Aim:

1. Explain how Virginian mathematical objectives would be the most suitable document to adapt to our educational setting. This will be achieved through providing staff with a comparative analysis between the New English Curriculum and Virginian math objectives. These were selected from the kinder and grade 4 curriculum documents. The task at hand was for all members to choose the objectives which they felt would best assist them to plan lessons and assess students' achievements.

2. To provide each year level coordinator with a list of mathematical objectives, specific to their year level.

Reaction of staff:

All staff members were given the task of choosing the objectives which they felt were easiest to plan lessons and assess student progress. Given 10 minutes, we discussed and compared the objectives. The staff did not know which document they had come from. All staff members chose the objectives in column B: stating that they were clear, more detailed and easiest to interpret. This lead into a 10 minute dialogue from the primary school math coordinator, explaining why the Virginian document was best suited to the school.

The junior school math coordinator provided additional information and justification supporting the benefits of the Virginian curriculum. Two staff member asked many questions, all of which highlighted that they were very resistant to the change. They continued to defend the old document that they had been previously using and struggled to comprehend why this change was necessary. The primary school math coordinator supported and explained that the results of the survey and KHDA inspections revealed that the staff were not using current mathematics teaching methodologies, and that the school had to implement a curriculum and not to continue to use the current mathematical scheme.

Main issues:

Two staff members:

– very resistant to change.

– defended old teaching methods

– stated they had used the document for many years and felt strongly about not changing to another program.

– defended the benefits of streaming, she felt as though it was not possible to cater for the diverse ability levels in one class.

– wanted to know what to tell parents about the new process

– felt as though the new curriculum would require too many resources and too much time to prepare and plan for

– was also concerned that students may not be equipped with the appropriate skills when they graduate to grade 7.

<u>Important dialogue:</u>

Staff member: *“I do not want to sound negative but why can’t we just continue using the scheme we have already, just implement it properly?”*

Staff member: *“We are not going to have all the resources necessary… in the past getting money for resources has been very difficult… I am not prepared to buy resources and pay out of my own pocket.”*

Staff member: *"Well, what will the planning document need to look like?"* (patronising tone)

Staff member: *"How will we make sure that all students are catered for within the class?"*

<u>Actions for next sessions:</u>

Review the math objectives within individual year level teams, adapt to cultural setting of school

– Begin to develop long-term scope and sequence plans based on new academic year time table

– Submit long-term scope and sequence plans within 2 weeks

Session Two

One-to-one meeting

Date: 12th May *Time:* 6pm *Duration:* 60 minutes

A private meeting between the primary school math coordinator (researcher) and a year level math coordinator. During this meeting the primary school math coordinator provided the year level math coordinator with more justifications and explanations why the changes were necessary. It became evident that the year level coordinator was struggling to accept the idea of change. After an hour long discussion, the year level math coordinator agreed to read the Virginian document, complete the long term scope and sequence plan and then express any additional concerns.

Session Three

One-to-one meeting

<u>Date:</u> 14th May <u>Time:</u> 1pm *<u>Duration</u>*: 60 minutes

A one-to-one meeting between the primary school math coordinator and a grade year level coordinator was held. The grade year level coordinator expressed concern that the content was too easy for students at their level. During this session a comparative analysis between the old math learning objectives and the new math learning objectives were discussed and some alterations were made to the Virginian objectives.

Session Four

Present in this meeting was the principal, the deputy principal of the junior school, the deputy principal of the primary school, primary school and junior school math coordinators and the grade K-6 year level coordinators.

Date: 14th May Time: 2:40pm *Duration*: 60 minutes

Aim:

1. Comparison of British Framework and VSOL (A/B tick-a-box sheet)
2. Outline why we are making changes (data collection from survey)
3. Outline why we are adopting VSOL (bridge to British, better support documents for teachers)
4. Go through scope and sequence document to demonstrate easy layout and resources – objectives, indicators, topics, activities, extension, assessment all provided. (Must email grade coordinators before meeting and ask them to bring their grade copy of VSOL Scope and Sequence so we can talk to it.)
5. Hand out copy of Grade 5/3 outline to walk them through it. Bring to attention:
    a. Activities taken directly from curriculum document
    b. Links to where Heinemann and other *resources* can be used

c. How language and mathematical reasoning are key to most activities

d. Assessment procedure: A) portfolio samples used as formative assessment (often in-class, observation, anecdotal, discussion based with simple outcome-based grading system) B) topic assessments are both formative and summative assessment (grading system needs to be decided on) C) End of year skills and knowledge-based assessment/examination as summative assessment and used for reporting to parents (keep those parents happy who like to see an end of year exam!)

6. Address any concerns that have been presented to us to date and action decided/taken:

    a. Language – change to metric, dirhams, etc, but also introduce other currencies as it is an international school, develop a language bank for each concept and topic taught – share with ESL teachers

    b. Informing parents – host parent information nights at the start of next academic year to inform parents on how change to new curriculum will benefit their child, and how they can support their child at home – ‘fun with Maths’ nights for parents and kids

7. Question time

Reaction of staff:

– One staff member was not on board.

– Others seemed to agree that the change was possible and necessary.

Main issues:

– The main concern raised was that the curriculum was too easy for the children and this had presented problems in the past. (This concern was brought up by a different grade coordinator.)

Important dialogue:

Grade coordinator: *“This (Virginian) document is too easy for the children and in the past when the school had a math reform and made the change from the British curriculum to American curriculum some children missed out on learning certain mathematical concepts and hence my daughter was one of those children who suffered as a result of it.”*

Grade coordinator: *“I have had a meeting with the primary math coordinator and we were able to negotiate on the math objectives and make some changes which will best suit the needs of the children in this setting… I feel much more comfortable with implementing the standards now.”*

Actions for next sessions:

Math coordinators will have one-to-one sessions with any year level coordinators who feel that the math objectives from the Virginian document needs adapting.

K-6 grade coordinators were invited to join the K-6 year level math coordinators to the next meeting - which will be developing the daily lesson plans incorporating the new teaching methodology.

Following this meeting, the primary school math coordinator developed a comparative analysis between the Heinemann scheme year 2 math objectives and the corresponding Virginian objectives. The exact gaps were highlighted and adaptations were made to the Virginian document.

Session Five

Present in this meeting was the 4-6 year level math coordinators, some members of their team, junior and primary school math coordinators and junior school deputy principal.

Date: 1st June, 2008 Time: 2:40pm *Duration*: 60 minutes

Aim:

1. To guide staff through the process of developing the daily plan, using a template which incorporates new teaching methodologies (small group focus, using concrete aids, etc)

2. Explain organisation of daily math lessons i.e. whole\part\whole

Reaction of staff:

– All staff, except for the one grade math coordinator, had prepared for the meeting and developed the year scope and sequence.

– Staff had many questions regarding the process of differentiation and targeting small group learning.

– All staff, except for one grade math coordinator, were able to work together during the lesson to develop their first week plan.

Main issues:

– Some staff members were still defending streaming children into ability classes.

Reaction of staff:

– Two staff members were reluctant to put in the effort

Important dialogue:

Grade math coordinator: *"I was not asked to be in this position, I was just told that I had to be math coordinator when I started in this school (4 years ago)… this is too much work… I do not have time…"*

Actions for next sessions:

– Submit first week math plan for new academic year by 10th of June.

– Assessment paperwork will be provided next week, outlining student data that will be collected for their portfolios.

Session Six

Present in this meeting was the K-3 year level math coordinators, some members of their team, junior and primary school math coordinators and primary school deputy principal.

Date: 2nd June *Time*: 2:40pm *Duration*: 45 minutes

Aim:

1. To guide staff through the process of developing the daily plan, using a template which incorporated new teaching methodologies (small group focus, using concrete aids, etc)

2. Explain organisation of daily math lessons i.e. whole\part\whole

Reaction of staff:

– All staff prepared for the meeting. They had all completed the term scope and sequence.

– Everyone seemed positive

Main issues:

– If they could use additional resources

– Assessment

<u>Actions for next sessions:</u>

– Submit first week math plan for new academic year by 10th of June.

– Assessment guidelines will be provided next week, outlining student data that will be collected for their portfolios.

Survey Number:

Appendix Three

Private International School: Mathematics Questionnaire

Question One

1.1 How many years of mathematic teaching experience do you have?

____

Listed below are questions about the types of activities that students engage in during mathematics. For each activity, you are asked to estimate the relative amount of ***time*** *a typical student will spend engaged in that activity during classroom instruction over the course of a school year.*

AMOUNT OF INSTRUCTIONAL TIME (for the school year)

0 - None
1 - Little *(10% or less of instructional time for the school year)*
2 - Some *(11-25% of instructional time for the school year)*
3 - Moderate *(26-50% of instructional time for the school year)*
4 - Considerable *(50% or more of instructional time for the school year)*

Question Two

How much of the total mathematics instructional time do students:	None	Little	Some	Moderate	Considerable
2.1Watch the teacher demonstrate how to do a procedure or solve a problem.	0	1	2	3	4
2.2 Take notes from lessons or the textbook.	0	1	2	3	4
2.3 Complete *computational exercises or procedures* from a textbook or a worksheet.	0	1	2	3	4
2.4 Present or demonstrates solutions to a math problem to the whole class.	0	1	2	3	4
2.5 Use manipulatives	0	1	2	3	4

2.6 Work *in pairs or small groups* on math exercises, problems, investigations, or tasks.	0	1	2	3	4
2.7 Do a mathematics activity with the class outside the classroom	0	1	2	3	4
2.8 Use computers, calculators, or other technology to learn mathematics	0	1	2	3	4
2.9 Take a quiz or test	0	1	2	3	4
2.10 Solve *word problems* individually from a textbook or worksheet	0	1	2	3	4
2.11 How often do children work in differentiated groups?	0	1	2	3	4

Question Three

When students use *hands-on materials,* how much time do they:

3.1 Measure objects using tools such as rulers	0	1	2	3	4
3.2. Measure objects using tools such as scales	0	1	2	3	4
3.3 Build models or charts	0	1	2	3	4
3.4 Collect data by conducting surveys.	0	1	2	3	4
3.5 Present information to others using manipulatives (for example, chalkboard, whiteboard, posterboard, projector).	0	1	2	3	4

Question Four

How often do you use each of the following when assessing students in mathematics class:

4.1 Objective items (for example, multiple choice true/false).	0	1	2	3	4
4.2 Short answer questions such as performing a mathematical procedure.	0	1	2	3	4

4.3 Extended response item for which student must explain or justify solution.	0	1	2	3	4
4.4 Performance tasks or events (for example, hands-on activities).	0	1	2	3	4
4.5 Individual or group demonstration, presentation.	0	1	2	3	4
4.6 Mathematics projects.	0	1	2	3	4
4.7 Systematic observation of students	0	1	2	3	4

Question Five

Please indicate the importance of the following elements when planning:

5.1 Making connections to real life experiences 'tuning in'	0	1	2	3	4
5.2 Differentiated groups	0	1	2	3	4
5.3 Critical thinking	0	1	2	3	4
5.4 Assessment (formative/summative)	0	1	2	3	4
5.5 Extension activities	0	1	2	3	4
5.6 Technology (MIMIO ect)	0	1	2	3	4
5.7 Resources	0	1	2	3	4
5.8 Follow up home activities	0	1	2	3	4
5.9 Heinemann resources	0	1	2	3	4
5.10 Vocabulary	0	1	2	3	4
5.11 Teacher instruction	0	1	2	3	4

5.12 Student activity	0	1	2	3	4
5.13 Type of learning style	0	1	2	3	4
5.14 Type of teaching style	0	1	2	3	4
5.15 Timing of lesson/number of lessons	0	1	2	3	4
5.16 Key ideas	0	1	2	3	4

Question Six

Please indicate the role of current assessment:

6.1. How often do you use assessment to inform your teaching?	0	1	2	3	4
6.2. Do the assessment results provide diagnostic evidence for future learning?	0	1	2	3	4
6.3. Do you use assessment results to accurately establish differentiation within the classroom?	0	1	2	3	4
6.4. How often do you use formative assessment?	0	1	2	3	4
6.5. How often do you use summative assessment?	0	1	2	3	4

Appendix Four

GRADE 5

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1.

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Framework planner Year 5 Autumn Term Record of Work

Unit 1	TB 1	TB 2	TB 3	HA 1	CU 1

Place value, ordering and rounding using a calculator

Unit 2	TB 35	TB 36	HA 9	CU 11	TB 37	TB 38	TB 39	HA 10	CU 12	TB 40	TB 41	HA 11	CU 13

Unit 3	TB 47	TB 48	TB 49	HA 12	CU 14	TB 50

Unit 4	TB 56	HA 13	TB 57	CU 17	TB 58

Unit 5	TB 62	TB 63	HA 15	CU 19	TB 64	TB 65	TB 66	HA 16	CU 20

Fractions decimals and percentages
Ratio and proportion

Unit 6	TB 119	TB 120	TB 121	TB 122

Handling data, using a calculator

Unit 8	TB 104	TB 105	TB 106

Unit 9	TB 89	TB 90	TB 91	TB 92	TB 93	TB 94	EX 13

Unit 10	TB 82	TB 83	TB 84	EX 14	EX 15

Unit 11	TB 13	TB 14	TB 15	HA 3	CU 5	TB 25	HA 6	TB 26	TB 27	CU 8

Unit 12	TB 4	TB 5	HA 2	TB 6	TB 7	EX 1

properties of numbers,
reasoning about numbers

GRADE 5 MATH PLAN 2005-2006

Appendix A: NHM5 Framework planner

Unit	Topics	Objectives
1	Place value, ordering and rounding Using a calculator	[illegible]
2-3	Understanding × and ÷ Mental calculation strategies (× and ÷) Pencil and paper procedures (× and ÷) Money and 'real life' problems Making decisions and checking results, including using a calculator	[illegible]
4-5	Fractions, decimals and percentages Ratio and proportion	[illegible]
6	Handling data Using a calculator	[illegible]
7	Assess and review	
8-10	Shape and space Reasoning about shapes Measures, including problems	[illegible]
11	Mental calculation strategies (+ and −) Pencil and paper procedures (+ and −) Money and 'real life' problems Making decisions and checking results, including using a calculator	[illegible]
12	Properties of numbers Reasoning about numbers	[illegible]
13	Assess and review	

Year 5: Autumn Term

NHM Topic	Math Section	Pages	Date Completed
Numbers to Millions	[illegible]	38–41	SEPTEMBER 18/09/05
Multiplication	[illegible]	132–136	
	[illegible]	137–143	SEPTEMBER
Division	[illegible]	166–171	OCTOBER
Fractions	[illegible]	[illegible]	OCTOBER
Decimals	[illegible]	[illegible]	
Data Handling	[illegible]	[illegible]	OCTOBER
2D Shape	[illegible]	[illegible]	
Length	[illegible]	[illegible]	NOVEMBER
Area	[illegible]	[illegible]	
Addition	[illegible]	74–79	
Subtraction	[illegible]	[illegible]	NOVEMBER
Numbers to Millions	[illegible]	49–51	DECEMBER 7/12/05

EXAM WEEK 10/12/05

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GRADE 5 TERM 2 MATH PLAN

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Framework planner Year 5 Spring Term Record of Work

Unit 1	TB 8	TB 9	CU 3						
Unit 2	TB 42	TB 43							
Unit 3	TB 51	TB 52	CU15						
Unit 4	TB 59	HA 14	TB 60	TB 61	CU 18				
Unit 5	TB 107	TB 108	EX 16	EX 17	EX 18	TB 109	TB 110		
Unit 7	TB 85	TB 86	HA 17	TB 87	TB 88				
Unit 8	TB 95	TB 96	TB 123						
Unit 9	TB 16	HA 4	TB 17	TB 18	TB 19	TB 20	CU 6		
Unit 10	TB 28	HA 7	TB 29	TB 30	CU 9	TB 31	HA 8	TB 32	CU 10
Unit 11	TB 77	TB 78	TB 79						

Framework planner G5 TERM 2 MATH PLAN 5RW

Year 5: Spring Term

Unit	Framework topic	Objectives children will be taught to ...	NHM Topic	NHM Section	Teaching file pages	Date/comments
1	Place value, ordering and rounding; Using a calculator	[illegible]	Numbers to Million	[illegible]	[illegible]	JANUARY 31
2–3	Understanding × and ÷; Mental calculation strategies (× and ÷); Pencil and paper procedures (× and ÷)	[illegible]	Multiplication	[illegible]	[illegible]	
	Money and 'real life' problems; Making decisions and checking results, including using a calculator	[illegible]	Division	[illegible]	[illegible]	FEB
4	Fractions, decimals and percentages; Using a calculator	[illegible]	Fractions	[illegible]	[illegible]	FEB
5	Shape and space; Reasoning about shapes	[illegible]	2D Shape	[illegible]	[illegible]	FEB–
		[illegible]	3D Shape	[illegible]	[illegible]	MARCH
6	Assess and review					
7–8	Measures, including problems	[illegible]	Time	[illegible]	[illegible]	
		[illegible]	Weight	[illegible]	[illegible]	MARCH
	Handling data	[illegible]	Data Handling	[illegible]	[illegible]	
9–10	Mental calculation strategies (+ and −); Pencil and paper procedures (+ and −); Money and 'real life' problems; Making decisions and checking results, including using a calculator	[illegible]	Addition	[illegible]	[illegible]	
			Subtraction	[illegible]	[illegible]	MARCH
11	Properties of numbers; Reasoning about numbers	[illegible]	Number Properties	[illegible]	[illegible]	MARCH 29
12	Assess and review					

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GRADE 5 TERM 3 MATH PLAN

Framework planner Year 5 Summer Term Record of Work

Unit 1	TB 10	TB 11	TB 12	CU 4							
Unit 2	TB 44	TB 45	TB 46	EX 5							
Unit 3	TB 53	TB 54	TB 55	CU 16	EX 6	EX 7					
Unit 4	TB 67	TB 68	CU 21	TB 69	EX 8	TB 70	TB 71				
Unit 5	TB 72	TB 73	TB 74	EX 9	TB 75	TB 76	EX 10				
Unit 6	EX 19	EX 20	EX 21	EX 22							
Unit 8	TB 111	TB 112	TB 113	TB 114							
Unit 9	TB 115	TB 116	TB 117	TB 118							
Unit 10	TB 97	TB 98	TB 99	TB 100	TB 101	TB 102	TB 103				
Unit 11	TB 21	TB 22	HA 5	TB 23	TB 24	CU 7	EX 2	TB 33	TB 34	EX 3	EX 4
Unit 12	TB 80	TB 81	EX 11	EX 12							

Framework planner GRADE 5 TERM 3 MATH PLAN

Year 5: Summer Term

Unit	Framework Topic	Objectives: children will be taught to ...	NNM Topic	NNM Section	Teaching File pages	Date/comments
1	Place value, ordering and rounding Using a calculator	• Use the vocabulary of estimation and approximation. [illegible] • Estimate by approximating (round to nearest 10 or 100), then check result. • Develop calculator skills and use a calculator effectively.	Numbers to Millions	• Estimating and rounding [illegible]	60–67	APRIL 17 -22
2–3	Understanding × and ÷ Mental calculation strategies (× and ÷) Pencil and paper procedures (× and ÷) Money and 'real life' problems Making decisions and checking results, including using a calculator	• Understand the effect of and relationships between the four operations [illegible] [illegible] • Develop calculator skills and use a calculator effectively. • Check with the inverse operation when using a calculator. • Check with an equivalent calculation.	Multiplication Division	• Written methods of multiplication [illegible] • Dividing three-digit numbers; remainders [illegible]	193–197 178–182	APRIL 22 ↕ MAY 6
4–5	Fractions, decimals and percentages Ratio and proportion	• Use decimal notation for tenths and hundredths. [illegible] • Begin to understand percentage as the number of parts in every 100 [illegible]	Decimals Percentages	• Tenths (cont.) [illegible] • Hundredths [illegible] • Percentages [illegible]	216–221 232–240 243–250	MAY 6 ↕ MAY 13
6	Handling data Using a calculator	• Solve a problem by representing and interpreting data in tables, charts, graphs and diagrams [illegible] • Find the mode of a set of data.	Data Handling	• Using the Data Handling processes (cont.) [illegible]	375–380	
7	Assess and review					
8–10	Shape and space Reasoning about shapes Measures, including problems	[illegible]	Position, Movement and Angle Volume/Capacity Mixed Measures	• Position, movement and angle [illegible] • Volume/Capacity [illegible] • Mixed measures [illegible]	304–311 318–323 326–330	
11	Mental calculation strategies (+ and −) Pencil and paper procedures (+ and −) Money and 'real life' problems Making decisions and checking results, including using a calculator	[illegible] • Check with the inverse operation when using a calculator. • Check with an equivalent calculation.	Addition Subtraction	• Addition involving four-digit numbers [illegible] • Written methods of subtraction [illegible]	87–92 120–125	MAY 13 ↕ MAY 17
12	Properties of numbers Reasoning about numbers	• Make general statements about odd or even numbers, including the outcome of sums and differences. [illegible] • Know squares of numbers to at least 10 × 10. • Find all the pairs of factors of any number up to 100.	Number Properties	• Number properties [illegible]	266–271	
13	Assess and review					

GRADE 5 MATH PLAN 2005-2006

Appendix A: NHM5 Framework planner

Unit	Topic	Objectives
1	Place value, ordering and rounding Using a calculator	[illegible]
2-3	Understanding × and ÷ Mental calculation strategies (× and ÷) Pencil and paper procedures (× and ÷) Money and 'real life' problems Making decisions and checking results, including using a calculator	[illegible]
4-5	Fractions, decimals and percentages Ratio and proportion	[illegible]
6	Handling data Using a calculator	[illegible]
7	Assess and review	
8-10	Shape and space Reasoning about shapes Measures, including problems	[illegible]
11	Mental calculation strategies (+ and −) Pencil and paper procedures (+ and −) Money and 'real life' problems Making decisions and checking results, including using a calculator	[illegible]
12	Properties of numbers Reasoning about numbers	[illegible]
13	Assess and review	

Year 5: Autumn Term

NHM Topic	Main teaching	Teaching File pages	Date/comments
Numbers to Millions	• Number sequences to millions [illegible]	38-41	SEPTEMBER 18/09/05
Multiplication	• Multiplication by 10, 100 [illegible] • Mental strategies [illegible]	130-136 137-143	SEPTEMBER
Division	• Dividing by 2-10, 100, 1000 [illegible]	166-171	OCTOBER
Fractions	• Fraction of a shape; equivalence [illegible]	192-203	OCTOBER
Decimals	• Tenths [illegible]	218-231	
Data Handling	• Using the Data Handling processes [illegible]	379-386	OCTOBER
2D Shape	• 2D Shape: properties [illegible]	333-335	
Length	• Length [illegible]	348-358	NOVEMBER
Area	• Area [illegible]	374-384	
Addition	• Doubles and near doubles [illegible]	74-79	NOVEMBER
Subtraction	• Mental subtraction [illegible]	100-105	
Numbers to Millions	• Place value, comparing and ordering [illegible]	45-51	DECEMBER 7/12/05

EXAM WEEK 10/12/05

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Framework planner Year 5 Spring Term Record of Work

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Unit 2	TB 42	TB 43

Unit 3	TB 51	TB 52	CU15

Unit 4	TB 59	HA 14	TB 60	TB 61	CU 18

Unit 5	TB 107	TB 108	EX 16	EX 17	EX 18	TB 109	TB 110

Unit 7	TB 85	TB 86	HA 17	TB 87	TB 88

Unit 8	TB 95	TB 96	TB 123

Unit 9	TB 16	HA 4	TB 17	TB 18	TB 19	TB 20	CU 6

Unit 10	TB 28	HA 7	TB 29	TB 30	CU 9	TB 31	HA 8	TB 32	CU 10

Unit 11	TB 77	TB 78	TB 79