

**Development of a model to support professional development of
primary mathematics teachers in Mauritius**

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**Thesis submitted to the Senate of the University of KwaZulu-Natal in
fulfillment of the requirement for the degree of Doctor of Philosophy**

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South Africa**

March 2005

(9) 912605

HCO6/07441

Declaration

I hereby declare that this study represents original work by the author and has not been submitted to another university. Where use has been made of the work of others, this has been duly acknowledged.

Signed by:

Premanund Moorgawa



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Acknowledgements

First and foremost, I am deeply grateful to my supervisor Prof. Alan Amory for giving me this unique opportunity to research a real-life educational problem having commonalities with other Southern African Development Community (SADC) countries. I also wish to dedicate a special thanks to him, who, beyond the exceptional guidance and supervision, triggered a spark for philosophy and educational psychology that subsequently grew into an ember glowing within me all through my research studies.

I am also grateful to the staff of the Information and Technology Education (ITEd), in particular Kathy Murrell for initiating me to the Open Learning Software (OLS) system and teaching me, with her perfectionist style, to unlearn the amateurish way of text formatting, to Patsy Clarke for guiding me through QSR NVIVO software, and to Jeethend Ranjeeth for technical support in the Research LAN.

Thanks also to my colleagues of the Department of Mathematics & Computer Education, Mauritius Institute of Education for allowing me a lighter lecturing workload to enable me do justice to my studies. Thanks to the pre-service, in-service teachers, school administrators, and primary school inspectors who freely accepted to participate in the surveys. Thanks to the Director, Planning and Project Analysis, Mauritian Ministry of Education & Scientific Research who, in spite of his hectic schedule, offered me the opportunity to discuss the proposals and recommendations in this research study.

A special thanks to the staff of the Mauritius Institute of Education Library and the Interlibrary Loan Section of the University of KwaZulu-Natal.

Last but not least, I am thankful to my wife and children who bore stoically my years of lucubration and periodic absences from home. Finally, to Pristie, my granddaughter, whose thoughts always cheered and comforted me while away from home.

Abstract

This study reflects the phenomenological and empirical description of the researcher's experience as a secondary school teacher, teacher educator and researcher at a teacher training institute. The study was prompted by low performance and high drop outs of children in the primary schools of Mauritius. In the course of the investigations, a variety of collateral and related issues spawned from the study of the main theme. These focused on three main educational issues being at the heart of the reform process undertaken in Mauritius: undergraduate teacher preparation programs, continuing professional development of teachers, and curriculum restructuring.

The first issue addresses the problem of pre-service teacher preparation programs and its impact on efficiency, effectiveness and efficacy of teachers. The second concerns the provision of professional development opportunities to teachers and its impact on the performance of students and overall school improvement. The third focuses on the need for curriculum restructuring in a context where, with the advent of the information society, the educational landscape is changing to accommodate computer technology as a cognitive tool. The thesis also focuses on the impact of teachers' development on school performance and makes recommendations for improving schools' overall performance through teacher development, computer technology, and curriculum restructuring. The phenomenological dimension of the study relates to the search for a pedagogical-andragogical-technological solution to the problem of continuing professional development of teachers.

Chapter 1 provides an overview of the educational system in Mauritius within focus on the role of teachers from a modernist perspective. The chapter also provides the rationale for change from a postmodern perspective. Chapter 2 provides a review of literature on teacher development, preparation programs for trainee teachers, and the problematics of elementary school mathematics from a constructivist perspective. Chapter 3 deals with problems of investigating research paradigms and the search for methodological stances for the investigations. Chapter 4 deals with the analysis of the research data. Chapter 5 describes the findings and provides the bases for formulating the proposals and recommendations.

The study is based on a diversity of research methods that in fact transcend the narrow standards of traditional empirical research. The researcher had recourse to a range of methods, based on an eclectic approach that drew from developmental research and a combination of ethnographic and

hermeneutics research, in investigating contemporary teaching, learning and curriculum development processes in order to provide a concrete, theoretically-based direction for organizing the investigations. The approaches, in a sense, are mutually intertwined and provide a basis for investigating and making suggestions on how teacher development and curriculum ought to be or *could* be. Much of the study has been driven by postmodern thinking in pursuit of a rationale to bring a re-conceptualization of teacher training and development, and curriculum change. In this respect, the researcher may be regarded as a 'self-styled postmodernist' adopting a questioning epistemology to investigate the objective reality created by modernism.

The scientific notation has been used to link the different sections of the text for ease of reference. It is expected that the findings and recommendations will be found to be useful to decision- and policy-makers and may guide further research in the field of teacher education in Mauritius. It is hoped that this thesis will contribute to enrich the burgeoning research literature on Mauritian education.

Glossary

ACE	Advanced Certificate in Education. ACE is an upgrade program for primary school teachers having a minimum of six years teaching experience.
COMESA	Common Market for Eastern and Southern Africa. The Treaty establishing COMESA was signed on 5th November 1993 in Kampala, Uganda.
CPE	Certificate of Primary Education. This certificate is offered to primary school children passing written examinations at the end six years of schooling.
CPD	Continuing Professional Development.
GCE	General Certificate of Education.
GCSE	General Certificate of School Examination.
ICT	Information and Communications Technology.
ITE	Initial teacher education.
MIE	Mauritius Institute of Education. The MIE is the unique training institution in Mauritius.
PDS	Professional Development School.
PRB	Pay Research Bureau. A parastatal organization for salary revision and pay awards.
PSSA	Private Secondary School Authority. This authority has mandate to manage privately-owned secondary schools.
SADC	Southern African Development Community. SADC is an economic grouping of 15 sub-Saharan African countries (including Rwanda).
TCP	Teacher's Certificate Primary. A certificate offered to pre-service teachers at the end of a two-year course.
TDP	Teacher's Certificate Primary. TDP is an in-service upgrade program for elementary schools teachers.

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It is the supreme art of the teacher to awaken joy in creative expression and knowledge
- Albert Einstein.

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Chapter 1

Introduction

1.1 Background to the study - introduction

This chapter provides the background to the research study. It unfolds the research terrain within which this study of practicing teachers is pitched from the perspective of the researcher as a professional teacher trainer based at the Mauritius Institute of Education for the past two decades. It investigates teacher education issues and the role of emerging technologies within a historic-geographic, and socio-economic condition. It cuts across the teacher education program, learning needs of practicing teachers, and the need for curriculum reform as a response to societal demands. It also highlights the problematic nature of teacher education in terms of initial teacher education (ITE), professional development of practicing teachers, the problem of primary school mathematics curriculum reform, and the role of emerging technologies in determining the changing nature of society's expectation of the educational enterprise.

Mauritius is a small democratic and sovereign island in the Indian Ocean with a multi-racial, multi-ethnic and multi-cultural society. It has adopted a Westminsterian type of parliamentary democracy with universal suffrage. It has experienced a history of four centuries with slavery from Africa, indentured labor from India and settlement of Europeans. Today, Mauritius serves as a beacon for Africa with a prosperous economy based on agriculture, textile, tourism and the services. The country has a fast booming economy with the advent of cybercities, and is poised to become a 'knowledge hub' and a duty-free island state opening out to the rest of the world.

There is a growing recognition in educational circles that teacher development is a most critical component of professional development programs for improving and reforming education. The

present decade is witnessing a new paradigm in human resource development that tends to be associated with new electronic tools and emerging technologies in a process to revolutionize the traditional training and development perspectives in order to meet new challenges and the growing demands for training and upgrading of professional skills. This perspective on education and training has been further reinforced with the information explosion accompanying the emergence of the World Wide Web (WWW), interactive multimedia, and computer-mediated communication (CMC) of the previous decade. With these, and a spate of other technological developments, namely, computer conferencing, the world has indeed been 'down-sized' to what McLuhan (1964) termed the Global Village. Indeed, with the advent of electronic technology the world is in a state of transformation from the industrial age to the information age.

The information and communications age has ushered in a new world order based on the digital media. We live in a networked, wired world that fosters one-to-one communication. This technological revolution, brought about by the Internet and the World Wide Web (WWW), is unparalleled in the history of digital media; it has, as a cultural revolution, virtually swamped all nations of the civilized world. As a medium for global communication, it transcends barriers and cultures across continents to permeate working habits of people, societies, and institutions in general. Its influence has left no country untouched; its power of dissemination and 'invasion' is so fast and incursive and its influence so pervasive that, very likely, it will have a profound and lasting effect in every aspect of human endeavor. We are already witnessing the rate of the accompanying change in the technology is so fast in pace and vast in scope that the biggest of challenges of this decade will remain effective change, innovation, their management, and how to adapt and adopt in order to be able to survive the technological onslaught of the information age.

In the globalized perspective that is unfolding ahead of us, today's professionals, whatever their sphere of endeavor, face challenging times. Yesterday's knowledge and skills cannot solve today's problems. Our knowledge and skills are fast rendered trite and outdated and, as a consequence, there is a perpetual need for constant renewal of skills and acquisition of new domain knowledge. There is a growing awareness that the new theories of learning and the accompanying problems of adaptation, adjustments, and realignments are posing serious challenges to today's professionals who perceive that, in order to stay in business, the need for continuous training and re-training is the norm in the twenty-first century.

This demand on professionals is becoming an important leverage for educational reform in the small island state of Mauritius¹ where development of human resources is a key factor in the economic and social development of the country (Master Plan, 1991). There is a general awareness in the need for moving this island state into the Information Age through massive investment in education to the extent that, for the period 2002-2003, 20 % of the national budget (with matching loans from the World Bank and the International Monetary Fund) have been allocated to the education sector. The national economic strategy enshrined in the Development Plan (2000-2005) is to transform this island nation into a 'knowledge-based' society within a cyber-island state.

1.2 The Mauritian setting

Mauritius is known in many countries worldwide, more specifically in the SADC (Southern African Development Community) region, as having achieved a reasonable level of economic and social development. The 'success story', often labeled as the 'economic miracle' of Mauritius, is attributable, in part, to its efforts in diversifying an economy based on a monoculture (sugarcane) to economically promising sectors like the Export Processing Zone (EPZ), tourism, offshore banking, and lately Information and Communications Technology (ICT). During the mid-seventies, while the EPZ was a burgeoning sector, the country underwent accelerated growth in the pace of its economic and social development. From that period onwards, the Gross Domestic Product (GDP) showed sustained periods of growth in excess of 6 per cent. During the period 1985-1995, the economic growth rate of Mauritius was probably the most phenomenal among the Indian Ocean rim countries. After a relatively sluggish growth between 1995-2000, the economy resumed its former buoyancy with the rate of economic expansion making per capita income rose among the highest in the SADC region². At the time of writing this thesis, Mauritius was deploying efforts at being privy with the economic development of the sub-Saharan African region by actively expanding economic cooperation through spearheading moves towards capital investment and technology transfer (in the context of the AGOA – Africa Growth and

¹ Mauritius is a newly industrialized country (NIC) with population of a little over 1.2 million (2002 figures), covering an area of 1840 km². It is an island republic located in the Indian Ocean just north of the Tropic of Capricorn, some 800 km east of Madagascar or some 2000 km from the east coast of Africa.

² Mauritius is rated among the upper middle-income countries with a *per capita* income of US\$4,594 (2003 World Bank figure), the highest in Africa.

<http://www.google.com/search?hl=en&lr=&q=Per+Capita+Income+for+Mauritius>. Accessed March 13, 2004.

Opportunity Act) through the bias of SADC and Common Market for Eastern and Southern Africa (COMESA) fora.

The above favorable macro-economic indicators masked, however, underlying problems. While the economy was undergoing radical transformation in its thrust to level off with the group of newly industrialized countries (NIC), the population growth rate (though under control and monitored by the Mauritius Family Planning Association - MFPA) and free education put enormous pressure on school capacity to accommodate the ensuing student explosion. Clearly, an increase in the critical mass of student population necessitated an increase in the number of the teaching workforce to cope with the student explosion. The introduction of compulsory education for children under 12 years (extended to 16 years in 2004) and the influx of expatriates and foreigners, who were massively investing in the new economy³, put further pressure on the system as a whole.

1.3 Reform in the education sector

The need for educational reform has been a major concern of most ruling parties since the country became independent from British rule in 1968. Successive governments have at various times proposed plans for reforming education but had to backtrack for lack of funds or for reasons of lack of general consensus around certain major issues at stake (for example, the problem of ranking at the CPE examinations).

The first attempt to initiate a major reform of the Mauritian educational system dates back to the 1991 with the publication of the Master Plan in Education. Conceived and designed by the Ministry of Education, the plan was intended to bring about the long-awaited reform in the pre-primary, primary and secondary institutions. Believed to be, at least in the public eye, a comprehensive, wide-ranging document that catered for every aspect of the Mauritian education (excluding tertiary), the plan seemingly missed out on several important issues. Reform of teacher education, the concept of lifelong education and the quality of education, the cornerstone of most reform processes, were given low profile. Other governments came up with tentative plans (some developed as part of electoral manifesto) to reform the education sector. Among these were the Action Plan (1998), the White Paper on Education (1996), Nine-year School Plan (1998), and the

³ Mauritius is ranked third place after USA and Europe in terms of foreign direct investment (FDI) for the period 1991-1998. <http://isidev.nic.in/pdf/Foreign%20Direct%20Investments.PDF>. Accessed March, 24, 2003

most recent, the Reform Plan of 2001. With the majority of the plans reflecting the ingredients of vote-catching political manifestos, and an exasperated public opinion impatient for change and innovation in an already antiquated educational system, minor sectorial reforms were undertaken in areas of elementary school curriculum renewal and upgrading of primary school teachers through in-service programs. The Master Plan on Education seemingly missed out on several important issues relating to reform of teacher education.

However, the bulk of the reform that was promised to the population did not get off the ground. Even at the best of times very few schools - 2 primary and 5 secondary - were built during the period of the economic upturn to cope with the demographic imbalance caused by a transitional economy, from agricultural to industrial vocation, and the institutionalization of compulsory primary education. Each plan engendered proposals for significant structural reforms and proposed solutions to major problems besetting the system, but in the public view, each plan was a concoction of varying ingredients with the same recipe for the long-awaited reform in education. According to Bhowon (1990), structural reforms do not coerce or induce behavioral reforms. We are always wrong in education as we always take for granted that behavioral changes can occur as a result of structural reforms. It was not until the year 2001 that the ruling party came up with a truly authentic plan (the Reform Plan of 2001) to engage the present educational reform process.

1.4 Contextualization of the study

This study is located in Mauritius, a member of the Southern African Development Community (SADC). It is important to understand the background and the specific context in which this research project is conceptualized. The title foregrounds, among other considerations, a popular educational theme relating to the professional development of primary mathematics teachers. The rationale for the provision of professional development programs and the means of implementing such programs through technology are core elements that tie up with many of the issues shaping the economic and human development perspective of a nation, which cherishes the vision of a 'knowledge-based society.'

Because of the dearth of research literature on the Mauritian educational system, policy makers and educational planners have relied mostly on the use of empirical and experiential data in the planning process. This thesis will provide a deeper insight into the human resource management

problem that has beset the educational system for many years. The study has as background the aspiration of some 7,000 primary schools teachers and the historical struggle to recognize their right to upgrade their professional competence and skills in a changing context of expanding task demands. In the sequel of this demand, many collateral issues have affected the system which has suffered in many ways. These will be discussed in the next section as these issues need to be addressed in depth and in an expedient manner as they are critical to the success of the educational reform being currently undertaken with the implementation of the Reform Plan.

1.4.1 Alternative route – subject teaching

Teachers' problems have in the main focused around issues of low pay, poor promotion prospects, lack of opportunities for professional development, pressures due to cognitive load and classroom fatigue. In an attempt to resolve the problem of overload and pressures on teachers, an alternative route to classroom teaching was proposed and implemented by government in 1994. The alternative scheme was to introduce subject teaching through a new categorization of teachers, namely restyling the post of 'general purpose teacher' to the 'subject teacher.' The new route represented a radical departure to a formula that categorized teachers according to subject domains and proposed to stream teaching into two substantive categories of subjects: one category of subject teachers to teach English and Mathematics, and the other French and Environmental Studies. This new formula, however, did not make much headway; it was implemented for a year or so and subsequently abandoned because teachers rejected the new and revised job structure. There is no evidence to suggest that the new job structure presumably affected their sources of additional 'untaxed' income accruing from private tuition.

Additionally, there has been a great deal of concern in the media and elsewhere about the scourge of private tuition that is rampant in the Mauritian education system. Whereas some support private tuition and call it a 'necessary evil,' on the ground that schools provide inadequate preparation for the competitive exam-oriented system of education; others regard it as deepening the inequity in the system: the wealthier parents afford to pay for more tuition than can poor parents (Joynathsing *et al.*, 1988). It is felt that teachers who unwittingly chose to revert to their general purpose status did so as part of a strategy to protect their vested interest. It should be underlined that the acceptance of the subject teaching formula represented a major trade-off for teachers in their efforts to upgrade their professional status. Its rejection brought nothing more than empathy to their cause.

1.4.2 Teacher's career curve

In Mauritius, the career curve of primary school teachers has a work span of 30-40 years and begins with initial teacher education (ITE) as pre-service trainee teachers. Trainee teachers are recruited by the Public Service Commission on the basis of an interview and a competitive written test. All prospective trainees for ITE must possess a minimum of five credits at Cambridge School Certificate (the equivalent of matriculation or General Certificate School Examination - GCSE), that includes English, French and Mathematics. New recruits are appointed trainee teachers on a two-year full-time pre-service course at the Mauritius Institute of Education (MIE) leading to the Teacher's Certificate Primary (TCP). (From January 2004, as part of the Reform Plan, trainees are recruited for a three-year full-time program leading to the Teacher's Diploma Primary – TDP.) After completion of the TCP, trainees are appointed in an substantive capacity as 'Certificated Teacher' of the general purpose category to teaching positions in the 256 primary schools of Mauritius.

1.4.3 The general purpose teacher

Unlike primary school teachers of the Asian category who are 'subject specialists' and are trained to teach a single oriental language (namely, Arabic, Hindi, Mandarin, Marathi, Telegu, or Urdu), general purpose teachers have the wider responsibility of teaching the overall primary school curriculum comprising English, French, Mathematics, and Environmental Studies to an age, ability, and aptitude of children in the age group five to thirteen years (Education Act, 1990). Obviously, the extent of knowledge specialization and skills of general purpose teachers are higher and much broader compared to single subject teaching of their Asian counterparts, yet the irony is that, in spite of the apparent disparity in the nature of training and workload, both categories are entitled to the same benefits in terms of salary and conditions of employment.

Although the basic qualification for entering the teaching profession is the Cambridge School Certificate or, equivalently, the Ordinary Level of the General Certificate of Education (GCE 'O' Level), obtained usually after 11 years of primary and secondary schooling, it has become the norm since the mid-1980s to recruit trainee with Higher School Certificate (the GCE 'A' Level equivalent), which is also the entry requirement for university entrance. The two-year (three-year from 2004) pre-service preparation at the MIE remains mandatory despite the fact that trainees possess qualifications higher than the minimum requirement and that could incidentally qualify

them as undergraduates if they chose to enter higher education at the university instead of joining the MIE as a trainee teacher.

1.4.4 Report on Teacher Education

It is common knowledge that despite the immense budget allocation for the educational sector (20% of the GDP for the budget year 2002-03), the relatively low pay rates and 'poor' promotion prospects in the primary sector do not attract graduates to the profession. Many developing nations have until recently been content with employing school leavers as primary school teachers after offering minimal ITE training. (The United Kingdom introduced its first graduate teaching force for primary schools in 1980.) The present structure of ITE has remained unchanged since it was introduced in the 1940s. It was not until a decade ago that the Report on Teacher education (Venkatasamy, 1991), commissioned by the government, made recommendations for upgrading teachers through in-service programs within the framework of the Master Plan for Education (1990). The report recommended, *inter alia*, a progression in teachers' development from Teacher's Certificate to Advance Certificate in Education (ACE), then to Diploma in Education (also known as Teacher's Diploma Primary), and ultimately to a Bachelor of Education (B.Ed). The proposals were to "help refresh the spirit and morale of teachers, and improve classroom teaching" (Venkatasamy, 1991, p. 21). The first upgrade program leading to the Advanced Certificate in Education (ACE) was offered in 1996 at the training institute, followed by the Teacher's Diploma Primary (TDP). The idea of extending to a B.Ed degree received no follow-up, probably for economic reasons.

In spite of these developments in teacher upgrade programs, the future of teachers entering the profession is much less uncertain in terms of career development, professional upgrade, and promotion prospects. Beyond the mere provision of initial training, there is indeed an urgent need for interest in staff development, overall school improvement and the quality of education.

The period 1940 – 1990 was relatively uneventful in terms of teacher growth and development in the education sector. It was also a period of massive unionization, which saw the growth of trade unions into becoming a labor force to be reckoned with. Meanwhile, the competitive nature of the primary education, which terminates with the Certificate of Primary Education (CPE) for 10-11 year olds, offered a breeding ground for the development of private tuition, a side 'business' after school hours that teachers practised to supplement their monthly incomes. Though not practised

by every teacher (although the majority is involved), private tuition, regarded as causing 'collateral damage' to children of poor families (who cannot afford to pay private tuition fees), has been 'institutionalized' in the educational system. In spite of its positive contribution to the teachers' purse, performance in schools has remained relatively low. The root problem that beset the Mauritian educational system centered around public dissatisfaction with performance in primary schools, low success rates at CPE (40 % failures for the past 12 years), high drop-out rates, and rampant private tuition that are incidental (or probably consequential) to a system offering free and compulsory education.

An event of paramount significance in the chronicle of the Mauritian education system occurred in January 1999: the government promulgated legislation to ban private tuition for children in lower primary classes (5 – 7 year olds) but offered school premises to be used as venues for private tuition for children in upper primary (8 – 10/11 year olds).

1.4.5 Status of teachers

A persistent issue of concern in the primary education sector has been the "status" of teachers. Being among the main causes of frustration and resentment among primary school teachers, the claim to upgrade teachers' status seems to be rooted in a growing dissatisfaction about low salaries, poor promotion prospects, lack of incentives, absence of planned teacher upgrading schemes, cognitive overload, and an ever-expanding task demand, especially with the implementation of the current reform plans in education. Clearly, this skepticism is bound up in public dissatisfaction about performance in schools, high drop-out rates, absence of a system of recuperation (for drop-outs), high failure rates at CPE, rampant private tuition, and the quality of education dispensed in primary schools. Perhaps the biggest shortcoming in the reform proposals has been the non-provision of professional development plans for serving teachers. Apart from the provision of in-service part-time upgrade courses (e.g. Advanced Certificate in Education and Teacher's Diploma Primary) the reform plans show no provision for on-going professional teacher development. The general feeling is that teachers are virtually 'left out' in schools after their initial training.

The social status of teachers is also related to the non-university character of teacher training institutions. Since it was set up in 1976, the MIE has been regarded as a tertiary institution with a non-university status. Its mandate has been laid out in the MIE Act of 1977, which stipulates that MIE is responsible for teacher education, educational research, and curriculum development.

Unlike the University of Mauritius which has open enrolment for its undergraduate and post-graduate programs, MIE relies on the Ministry of Education and the Private Secondary School Authority (PSSA) to channel school leavers and practicing teachers to its pre-service and in-service course intakes, respectively. This association of the MIE with the recruiting institutions for its clientele has inevitably affected the status of school teachers, with which (unlike the university) they have been closely associated in the public mind.

1.5 Traditional problems and changing needs

Teachers' struggle has marked the history of labor unrest in the primary educational sector since the 1980s. Lack of understanding the importance of teachers' learning needs and upgrading their professional status is an important variable in any reform process that relies on teachers to bring about the desired change and innovation in the nation's schools. However, providing school leavers with nominal training for a general certification in an age of growing specialization and employing them as general purpose teachers without planned provision for professional growth opportunities for a career spanning 30-40 years is a major limitation of the system. The success of the current reform agenda also depends on training institutions and the structure of teacher education programs in the wider context of staff development, including training of trainers and training of teachers. McKenzie (1991, p. 1) argues that "the traditional conceptions of staff development must be reconsidered and revised to support the kinds of adult learning which will bring educators enthusiastically to the cutting edge of practice without encountering the bleeding edge." The transition to the information age needs a new vision for change, more than a paradigm shift, "a metamorphosis as profound as the change from caterpillar to butterfly" (McKenzie, 1991, p.1). Teachers can no longer be regarded as the sole agents of change to bring about the new learning culture of the information age. Teachers cannot learn to become pioneers, inventors and shapers of this new culture; rather teachers should be trained in the new tools of the trade to utilize the state-of-the-art of this new age to enthuse new skills.

1.6 The reform in the primary education sector

The current educational reform has on agenda reforms in the primary and secondary education sectors. These comprise construction of new schools, extension and development of existing school infrastructures, organizational changes, and human resource development, more specifically upgrading teacher professional qualifications to the Advanced Certificate in

Education and subsequently to the Teacher's Diploma Primary. This study will not focus on the latter variable, namely upgrading teachers' professional qualifications through in-service programs organized by the MIE.

1.6.1 Professional development of teachers – the Mauritian scenario

Professional development as conceived in the Mauritian scenario is synonymous to upgrading teachers' qualifications through organized in-service courses leading to acquisition of additional qualifications. To what extent this form of upgrading is equated to professional development depends on two factors: first, the meaning attached to professional development as an on-going process of continuing education for raising professional standards, and secondly whether the nature of upgrading programs are geared to raising standards or intended to provide additional qualifications for gaining pecuniary benefits in terms of extra salary increments. The latter perspective seems to be favored by decision makers in order to attenuate teachers' perpetual claim for increases in salary. This model of teacher development attempts to improve teachers' status and is looked upon as a means to rejuvenate the spirit of professionalism after years of 'classrooming', and gives teachers a new lease of life and, most importantly, keep them 'going on' in an 'isolated' profession.

1.6.2 The problematic of initial teacher education (ITE)

Teacher education occurs at two levels – pre-service and in-service. The pre-service level, characterized by initial teacher education (ITE), is regarded a rather one-off exercise without provision for further professional training and development beyond the certification level. This is because most developing countries set limited funds for developmental education. The knowledge-base related to certification level is felt to be sufficiently adequate for the beginning teacher. Kolb (1984) asserts that for the most part, professional students on graduation are presumed to be competent for life. This derogation of professional education is partly responsible for lack of periodic reviews of ITE programs by way of incorporating research-based materials in an attempt to align program objectives along a global curriculum agenda.

Initial teacher education programs (ITE) in terms of subject matter knowledge (smk), pedagogical content knowledge (pck), propositional knowledge (Mewborn, 1999), classroom management and curriculum instruction have been known to be lacking in important aspects of pedagogy, technology education and instruction that tend to point to a deficit model of teacher preparation.

There is evidence in the literature that teacher development programs have shortcomings in teachers' behavior and practice that have roots in inadequate initial training that supposedly prepare teachers for a role for which continual upgrading and development becomes a regular feature in their career curve. Darling-Hammond (1999) highlights this concern in American reform efforts where reformers focus on increasing teachers' expertise and effectiveness as being factors critical to the success of ongoing efforts in school reforms. Darling-Hammond points out deficiencies in several areas, including subject matter knowledge (smk), pedagogical content knowledge (pck), child development, learning and learning theories, assessment, mentoring, curriculum, and technologies. Others argue that neither the knowledge, skills, and attitude (KSA) developed in preparation programs nor the powerful interventions of educators offering development programs can bring a real shake-up in the beliefs that teachers bring to initial teacher education. Moorgawa (2000) endorses this view with evidence from a study of would-be teachers who bring prior knowledge and belief of curriculum instruction to a preparation program, but which remain unchanged and even predominate long after they join schools to teach.

This deficit model tends to manifest itself in most educational reform efforts that advocate greater investment in teacher preparation and development, without paying due regard to the underlying problem of teacher certification, training program duration and subject content of teacher preparation programs to meet the needs of a new culture of learners. Furthermore, our model of ITE has shown its heuristics nature of meeting an economic imperative to respond to teacher shortage rather than prepare full-fledged teachers on the basis of a professional program that leads to the graduate teacher. The system of teacher recruitment and training has done no other than perpetuate the *status quo* that is reflected in our school performance and public desire for reform.

The other shortcomings of the ITE model are clearly visible in the absence of provision for the following epistemological dimensions of teacher preparation programs: (i) research in teacher education; (ii) the place of reflective thinking and inquiry-based approaches; (iii) the constructivist dimension in teacher preparation; and (iv) creativity in the elementary mathematics pedagogy. These four dimensions reflect the epistemic demands of teaching in the preparation of teachers for schoolwork. These will be examined and analyzed to gain a deeper insight into the epistemic dearth of a program that caters for a modernist era and that requires a complete overhaul and remolding to meet the demands of new generation of learners.

1.6.3 Failing standards in schools

The quality of education is a variable that depends to a large extent on the interplay of several factors having direct bearing on teacher effectiveness: of these the quality of teacher preparation programs, teacher knowledge, attitudes, values (KSA), continuing professional development, the curriculum, and the school environment being the most prominent. However, the issue of 40 % failures at CPE impacts adversely on the image of any country that eulogizes 96 % functional literacy and that prides itself of steering its economy to the development of a 'knowledge-based' society. The ratio of passes to failures at the CPE level (commonly known as the '60:40 performance ratio') is the major challenge facing any beginning teacher and is also the battle cry of every participating stakeholder in the educational reform process. A performance ratio of this magnitude is, among other reasons, at the heart of the problem plaguing the primary education system. The phenomenon is closely linked to the quality of education dispensed by teachers who have, surprisingly, passed through the MIE teacher preparation programs.

1.6.4 The problematic of the primary mathematics curriculum

It is a truism that the controversial nature of the pedagogy and didactics used in teaching the content of primary mathematics textbooks are partly blamed to be directed at 'high ability' students and to be largely responsible for the low performance and high drop-outs. It is claimed that the drop-outs of the primary school system are actually the 'push-outs' provoked by mathematics and mathematics instructions. The traditional approach to primary mathematics instructions has focused on problem-solving, a method directed towards development of computational skills, assessment through multiple choice questions (MCQ), and written examinations rather than promotion of conceptual and cognitive development fundamental to the study of mathematics. Furthermore, for over two thousand years, mathematics has been dominated by an absolutist paradigm, which views it as a body of infallible and objective truth, and as a static bounded discipline (Romberg, 1986).

More than thirty years ago, Hans Freudenthal pointed to a fundamental shortcoming of mathematics education according to which "pupils at all levels learn ready-made mathematics, instead of mathematizing" (p.511). Indeed, according to Edward Barbeau (1989, quoted in Romberg, 1986, p.750), "most of the population perceive mathematics as a fix body of knowledge long set into final form. Its subject matter is the manipulation of numbers and the

proving of geometrical deductions. It is a cold and austere discipline which provide no scope for judgment or creativity.” De Corte (1993, cited in Becker & Selter, 1996) argue that there is evidence showing that many pupils do not possess the knowledge, skills, beliefs, and motivation that are needed in order to efficiently approach problem solving in a changing world.

Many children are known for their inability to use basic mathematical competences and skills in real life. Moreover, children frequently see any connections between school mathematics and reality. The study of mathematics influences to a large extent the entire primary school curriculum to the extent that much of what is learned and taught is determined by how children find mathematics. Bhowon (1990) claims that primary education in Mauritius did not change in the last two hundred years or so of British colonial rule and it inevitably suffered of what Hughes (1967, p. 2) calls “sclerosis.”

1.7 Rationale for educational reform process

At the center of the current reform process are the pressures from various quarters. Pressures, which are inherently coercive, are the forces that drive administrators and funding agencies (the International Monetary Fund, the World Bank, and UNESCO) to respond positively in the interest of enhancing the quality of education and maintaining equity and standards in schools at an acceptable level.

Among the factors stimulating change are often pressures from both outside and within the school. Societal, economic and parental pressures account for the principal external stimuli to which decision makers normally respond in their effort to maintain equity, access and mandate which bring about school dynamism, stability and image. Internal pressures are due mainly to management concern for schools to conform to new requirements, such as those imposed by a National Curriculum (David, 1997). At the grassroots level, teachers demand that the changes benefit their students.

In the early 1960s, the priorities of preparation programs were to provide teachers with knowledge of content rather than the development of pedagogical and propositional knowledge. In the circumstances, to resolve teacher shortage, a one-year teacher training program leading to ‘certificated teacher’ status was deemed adequate to prepare the general purpose beginning teacher to enter the profession. The assumptions prevailing at the time the MIE was set up (1973)

was that the one-year program was inadequate to prepare individuals for a career spanning 30-40 years. With development educational research and the ubiquity of computer technology, the rationale for change to a two-year training program was justified and immediately implemented. But the damage done to the system as a consequence of poorly qualified teachers is immeasurable in terms of failure rates and drop-outs that characterized elementary schools for decades preceding the independence year of 1968.

1.7.1 Rationale of the study

The rationale of the study is inspired by a maxim on education due to Bertrand Russell that: "...every generation must overhaul its educational methods if time is to be found for what is new." The 'new' element in this context is the issue of professional development of teachers and how it ties up with the massive investment in digital technology of the late 20th century, its impact on adult learning and school improvement. The rationale is to explicate the relationship between the need for change associated with continuing professional education and training in the context of overall improvement. In this respect, the study focuses on the nature and effectiveness of teacher preparation programs, its relevance to teachers' learning needs and continuing professional development in an era of technological change. It examines teachers' needs from the perspective of instruction in the information age and educational reform. The rationale is aimed at developing a concrete, theoretically-based model for improving the teaching and learning processes through technological in(ter)ventions and curriculum change.

1.7.2 Postmodernism and the rationale for change

The term 'postmodernism'⁴ has seemingly defied, or rather resisted definition. Viewed from the perspective of modernism, Habermas (1983) considers postmodernism as 'anti-modernism,' while Lyotard (1989) posits postmodernism to be an 'incredulity towards meta-narratives,' (myth-like social justifications). Barrow (1999) argues that the term does not convey a clear meaning, is vague and too confused to be useful, and therefore lacks a coherent conception, but acknowledges that some of its central ideas and certain basic epistemological points "cannot in good faith be coherently denied" (p. 415).

Being short of a contextual definition renders postmodernism open to numerous interpretations, resulting in a multiplicity of referents (Atkinson, 2002). In an etymological sense, postmodernism is "post" to the modernity of the industrial age. By and large two theoretical strands of

postmodernism, identified from social theory, namely ludic postmodernism and resistance postmodernism, are amenable to the development of philosophical positions that have entered the mainstream of educational thinking in the information age. First, ludic postmodernism provides the perspective for the driving force in giving education the technological and constructivist orientations, especially when instruction and training are treated as commodities (Fox 1989, cited in Hlynka and Yeaman, 1992). Secondly, resistance postmodernism follows in the tradition of critical theory as a form of questioning, an attitude, or a perspective that provides the essence of 'the wheel of change' that provokes us to interrogate many, if not all, dimensions of educational practice that have resulted from the 'modernism' of the industrial society.

Whether regarded as the condition for a significant force or the basis of a philosophical approach, "postmodernism is not a theory or set of ideas as much as it is a form of questioning, an attitude, or perspective" (Kerka, 1997, p. 1). Based on this perspective, postmodernism has provided, in this study, the critical empowerment to engage in a process of enquiry, to look back, not in passive retrospect, but with critical hindsight at the educational phenomena created by modernism⁵. In this sense, the epistemic analysis of a philosophical position provides the basis for questioning, generating understanding and making meaning, interrogating our belief about objective truth and lifeworld as construed by our individual cognition, and developing new perspectives. However, when viewed as a mode of thinking, it may well offer a powerful leverage for educational change through the rejection of the *status quo*, the acknowledgement of diversity, and the refusal to accept a disruptive pedagogy (the perpetuation of which is inherently oppressive in favoring sectarian tendencies) that has led to the social divide in the Mauritian schools. In this perspective, postmodernism provides the driving force in the pursuit of a rationale to bring change, innovation and, interestingly, a new order in the field of education and training. Perelman (1990, quoted in Blacker, 1994, p. 2) prognosticates the importance of reform from this perspective as follows:

"(T)he nations that stop trying to 'reform' their education and training institutions and choose instead to totally replace them with a brand-new, high-tech learning system will be the world's economic powerhouse through the twenty-first century."

⁴ The term was originally applied in architecture but has since then been transferred to a wide range of spheres to explicate the ideas and belief accruing from modernism.

⁵ Modernism is characterized by the monolithic mindset of the industrial era that is impossible to maintain in the culturally diverse and fragmented world that we live in today (Wikipedia, 2003)

Reforming pre-service and in-service education through upgrading teachers' professional status or through professional development programs as currently conceived and delivered is highly unlikely to be of any value in the current educational reform process. It has departed radically from the modernist view that drove the provision of the educational agenda of the previous decades, and that based itself, among other things, on the 'grand narratives', for example, of what it is to be a teacher and what is the teacher's role in society. The shift from modernism to postmodernism offers a new dimension to the rationality of questioning the locus of the entire educational discourse from educational policy, planning and administration, schools, classrooms and teachers, to the processes of teaching and learning, curriculum and assessment. Taking such a stance calls within the purview of the researcher the forces that have perpetuated the artificial egalitarianism in primary education dispensed over a period of thirty-five years following independence of Mauritius, and the acceptance, within the system, of the deviant label (Keel, 2000) of 'social exclusion' that have benefited mostly those monitoring the progress and planning for change.

At this point it would be convenient to mention that, despite the call by UNESCO (1990), to provide the means for all children to access basic schooling while ensuring its quality for all, standards in schools have fallen well behind the target set, as has been variously mentioned in the previous section, with evidence corroborated from the Master Plan (1991). Classrooms, in most schools in the urban regions, are characterized by the social divide phenomenon, where children of the relatively rich and affluent are juxtaposed, while the poor and the disadvantaged are virtually relegated to the back seats of classrooms, not to say marginalized. The school admissions system has recently been revamped (in 2002) in favor of regionalization, a formula of admission designed to assign children to schools of their respective 'catchment area' (for ease of access). However, the measure actually bars children of rural areas, usually of families of laborers, artisans, small landowners (called '*petit planteurs*' in the Mauritian jargon), children from poor families and disadvantaged background, from the 'star' schools located in the cities. The paradox is that the practice of regionalizing admissions, while appearing sensible and realistic in the furtherance of reform on the basis of access and proximity of schools, masks a fundamental issue of mobility - the measure does not apply to the rich and affluent who seek to admit their children in private, fee-paying urban schools in the hope of a better education, even if primary education is free.

The concepts of 'equity' and 'social justice' advocated in educational circles and prevailing among modernist thinkers of the previous decades, have not had the desired effect in bringing social justice (through an equitable balance) and equality of opportunities desirable in developing countries' schools. It has been argued that postmodernism has no agenda for social justice, yet in recent years, the protagonist of postmodernism have given increasing attention to its value and usefulness to serve as a significant social lens to explore and interrogate educational practice, policy, and research. However, its critics have described it as 'unhelpful', and "irresponsible nihilism" (Atkinson, 2002, p. 74). Despite this perceptual ambivalence, postmodernism has offered us the empowerment of interrogating the context of our own actions and methods of preparing teachers. It has challenged our assumptions, conceptualization, and delivery of teacher programs for an emerging information society within the framework of educational reform and the need for improving quality of education within the wider discourse of change for a new social order. Whether viewed as an outgrowth of modernism, or "a theoretical virus which paralyses progressive thought, politics and practice" (Cole *et al.*, 1996, quoted in Atkinson, 2002, p. 73), the adoption of postmodernist thinking provides, with the advent of 'a postmodern culture' (Hughes, 1993), a theoretical framework for interrogating, articulating and reflecting the phenomenon of change in the wider discourse of the educational arena. Viewed from this perspective, there is a need for a re-conceptualization of the educational provision, more specifically in the field of teacher preparation and curriculum restructuring that is the legacy of the modernist era.

Griffiths (2000) highlights this concern by positing that in developing countries, schooling or 'education for all' do not necessarily translate in learning opportunities for all. While donor agencies, especially the World Bank which is the greatest single provider of funds to the education sector in developing countries, emphasize the economic development perspective (in which progress is measured on variables such as economic growth, national wealth and *per capita* gross national product (Griffiths, 2000)), the 'human development perspective' and the quality of education are the concern of individual governments. It would be reasonable to question the involvement of governments in improving the quality of education by, for example, providing learners with the sophisticated and marketable skills they need to participate in a knowledge-based society. The political hierarchy is known to be more concerned with equity and access rather than the quality of education to be dispensed to the present generation of children, while openly professing a policy of developing Mauritius into a 'regional education hub' (Prime Minister's New Year Message, 31st December, 2003).

1.7.3 Rationale for professional development

Professional development program's first order concern is directed towards helping teachers improve learning and participation of learners in overall improvement of school work and school activities. In the context of Mauritius, professional development is meant to address efforts at improving schools which in turn has a ripple effect on improvement in other areas of school life. This perspective is expected to lead to transformation in instructional methods by ensuring every child in the classroom participates fully in the enhanced learning processes taking place in the school campus. This first order concern is one shared by all participating teachers and teacher educators, and remains the central focus of teacher development. In this context, most teacher development programs take place as in-service education. Though initially conceptualized to enhance teacher status, evidence documenting the effectiveness of such programs in bringing teacher change is only now emerging. However, there is growing anecdotal evidence of practicing teachers working in isolation and left to their own devices with survival kits acquired from ITE programs to face the needs of a demanding career. Teaching is an isolated profession. A common perception of teaching is the tendency of teachers to work in isolation from their colleagues (Lieberman & Miller, 1992).

1.7.4 Rationale for reforming initial teacher education (ITE)

The traditional view of teacher preparation has been guided by the belief that the teacher's most solemn job is to instruct the young in the knowledge, skills, values, and behaviors that are determined by adult society. Though not welcomed by contemporary instructional theorists, traditional preparation programs tend to foreground the objectivist model of educating teachers. The objectivist view maintains that teachers are trained in the development of high-order thinking skills through knowledge that exists independent of instruction. Examples abound in initial teacher education (ITE) programs where trainees display least interest in the primacy effects of instructional materials geared towards development of higher-order thinking skills (e.g., probability theory, tessellation, theory of sets, etc.) and which are given higher ascendancy in vocationally oriented teacher programs where content knowledge and application are considered the prime survival strategies. The lecture method of the teacher educator determines extreme positions on the issue of whether trainees are to be trained into areas of the primary school curriculum, which includes, among other things, the 'know that', 'know how' and 'know why' of

teaching (Ovens, 1999), or to learn how to prepare lesson plans, what activities to follow to achieve pre-set objectives, ending with evaluation to see whether the objectives were met.

1.7.5 Rationale for curriculum reform

Pressures for curriculum reform usually come from politicians, administrators and the society to reflect changes in the social and economic structures of society. Developments in science and technology have also had profound implications for the current school curriculum to reflect the new demands in education. With the advent of the Internet and the World Wide Web (WWW), the trends in educational provision are changing: many educational institutions are posting their curriculum onto the web with the purport that a global audience accesses such materials. Such innovations are influencing curriculum restructuring efforts towards the globalization of content and knowledge.

The problem of restructuring curriculum is to ensure that a response is made to all the relevant pressures, and attempts made to surmount all the barriers. For curriculum restructuring to succeed, practitioners must hold a wider view of curriculum and manage the restructure to encompass all emerging demands in the educational system. The rationales leading to curriculum reform are many and varied, and these will be investigated in the next chapter.

The aims of education, in particular elementary mathematics education, are changing as a result of the following changes affecting the context of mathematics education:

(a) Changes in the pedagogy of mathematics. The biggest criticism, especially from societal perspectives, is that the elementary school mathematics curriculum has failed to remain relevant to the needs of children. Many children reaching Key Stage 1 (i.e. CPE examinations, after 6 years at school) are known for their inability to count money or perform simple measurements. In this respect, it is not the content that needs to be changed, but the method and practice of teaching mathematics have to be reviewed. Learning can no longer be viewed as a process of passively absorbing information and storing it as a result of repeated drill and practice and reinforcement. The focus of learning should be student-centered where students approach each task with some prior knowledge, assimilate new information, and construct their own meanings (Resnick, 1987). Student-centered pedagogy relies on constructivist approaches to learning through a combination of activity-based, inquiry-oriented, and discovery-based learning methods

and where computers and information technologies mediate the learning process. This constructive view of learning must be reflected in the way mathematics is taught.

(b) The epistemology of commonsense in mathematics teaching. Another perspective complementary to the above scenario is the commonsense approach to teaching as one remembers having been taught. (This option may be open to everyone, trained and untrained.) We teach in much the same way as we were taught. In this sense, teachers as adult learners are autonomous and self-directed (Lieb, 1991; Knowles, 1980). This maxim may seem to be the dominant view among those who lack formal pedagogical training, the uninitiated or new graduates entering colleges and universities to teach as lecturers. However, studies in the philosophy of Realistic Mathematics Education (RME) as evidenced by Freudenthal (cited in Heuvel-Panhuizen, 2003) privileges meta-functions¹ in the epistemology of concept formation in elementary mathematics instruction. The meta-functions are domain-specific instructional theory of mathematics education and are ideally based on the commonsense experiences of children.

The approach to children's learning should ideally include what children know (children's experiences) and how their experiences can be used in developing teaching strategies on the basis of a commonsense approach to learning. The curriculum should identify those areas of mathematics that are machine 'processable', gender friendly, and have a social orientation that shifts the areas of study to diversity with more choice for games and play. It is proposed a new curriculum should include, among other topics, computer games (children learn more about computers through computer games), mental arithmetic, measurements, modeling (to include situational modeling), graphs, two- and three-dimensional solids, estimation, and computer applications.

Effective teacher development entails knowledge of a scientific pedagogy based on the positivist views of educational psychology in order for training to be efficient and for teachers to become effective. Teaching based on the traditional pedagogy of direct instruction, pervasive in

¹ Meta-functions relating to concept formation in elementary mathematics instruction are guided by the tenets of Realistic Mathematics Education (progressive mathematization, guided discovery, and bridging), and include the Piagetian operational processes of child development (pre-, concrete, and formal). Other meta-functions, namely critical thinking, problem solving, connections/communications, reasoning, and visualization, are integral to the model.

traditional classrooms, inevitably help perpetuate the *status quo* (e.g. the 60-40 % performance ratio phenomenon) rather than challenge it. In this paradigm, teaching is viewed as a game of show-and-tell. Knowing something or to know how to do something is same as knowing how to teach that something. For these people teaching is a way of doing things, show-and-tell style. However, the days of “teach what you know” of the traditional classroom is making way for a new praxis, especially in progressive schools based on: “Teach what needs to be taught the way it is done pedagogically – trial-and-error style, with risk-taking.” As Jackson (1989, p. 126) puts it succinctly, the commonsense approach to teaching provides teachers basically

“with some notion, vague though it may be, of how to do many of the things teachers do – how to use blackboards, assign homework, correct papers, construct tests, conduct exams, give grades, lead discussions, deliver lectures, monitor seatwork, pass out materials, and more... . In short, it provides a set of norms for the would-be teacher, a veritable scrap-book of memories about how teachers in the past have acted, and, therefore, how one might oneself act in a similar situation.”

Although the application of commonsense to teaching is equally relevant to the uninitiated and untrained teacher, as a pedagogical approach it is crucial to the performance of everything we do. Reflective practice mediated with the dictates of commonsense tends to humanize instruction and contextualize learning within the experiences of the learner. For example, children’s knowledge about butterflies, frogs, or lizards can be realistically articulated to introduce the concept of ‘line symmetry’ in lower elementary classes. Similarly, children’s interest with pets (dogs, cats, etc.) can sensibly be modeled graphically (with Venn diagrams) to introduce the concept of set-theoretical representation, a topic that is gaining popularity in primary mathematics curriculum. These examples of commonsense behaviors to teaching rely on the mediated interaction of children’s experiences and interests and stimulate enthusiasm and help children deepen their knowledge and understanding. This pedagogy of commonsense must also be reflected in way mathematics is taught to children.

(c) *Changes in the role of technology.* Computers and calculators have changed our view of what mathematics is and how it is done. It is argued that all of the mathematical techniques taught from kindergarten to the first two years of undergraduate studies can be executed on hand-held (graphic) calculators. In particular, situations and experiences, complex or simple that are embedded with a time-dependent process are amenable to computer implementation. For example, from the simplest of topological equivalences dealing with the transformation of a circle into a rectangle or square, or vice versa, to the most complex of Einstein’s simplest metric spaces

can be reconstructed into a time-dependent process and hence implemented for computer processing. Additionally, computer exploration of any real mathematical concept (e.g. the concept of the degree – see OLS exhibits, Appendix 12) reveals cognitive involvement of a degree higher than a secular diversion based on a manual experience. Computers also provide learning environments (e.g. the ‘microworld’) that humanize the learning process, especially of mathematics, by providing a social context for constructing knowledge where students can engage collaboratively to explore basic mathematical concepts and processes.

(d) *Changes in the Mauritian society.* Over the past three decades, Mauritius has evolved into a society where the needs for scientific and technical knowledge have led to increased concern for the teaching of scientific subjects in schools. The transition to a newly industrialised country (NIC) status exerts extraordinary pressures on the teaching of mathematics (and science) education, pressures which led to several reform plans (see section 1.2.1) being drawn up in an effort to reform education. Alongside the reform plans, a boost to science education is being given by encouraging schools to use information and communications technologies in teaching. The new learning environment with the accompanying ‘technopush’ are meant to prepare a workforce for a new social and economic order looming ahead. The information age will require ‘information workers’ who can generate and consume information. Thus, societal demands for a new mathematic curriculum, with new approaches to mathematics education, and that ensure achievement across the entire demographic spectrum are both justified and urgent. It is also felt that there is a need for parallel development in enhancing teachers’ knowledge to cope with the need for curriculum change.

1.8 The challenges of the Information Age

The information age has ushered in new dimensions to teacher training and development, educational practice, the school and school life. There is general realization among educationalists and educators that teacher education and professional development efforts should focus on capacity building of teachers to respond to the needs of a new generation of learners. For the education of future generations, most professional development programs, as currently conceived, focus on one-week seminar/workshop, a day or two, after school classes, with an expert, intense summer immersion training, etc. These expedients have been mere palliatives to take away teachers temporarily from the boredom of school life and the routine of classroom work. Guskey (2002) points out that reviews of professional development research consistently

highlight the ineffectiveness of such programs. Some teachers view that the time spent in workshops and seminars serves merely as a 'refueling pause' to keep them 'airborne', without any effective gain in substantive additional knowledge and skills. Varieties of factors undoubtedly contribute to this ineffectiveness. It has been suggested that the majority of programs fail because they do not address short-term and long-term needs of teachers, schools and communities (Darling-Hammond, 1999).

At the core of any discussion of teacher development there is an urgent need to understand the nature of teachers' needs and task demands, that is what the teacher must be prepared to know and what to do. If teaching were viewed primarily as the transmission of information to students, one would argue that teachers need little more than the basic subject matter knowledge (smk) to be able to teach. Effective teaching in the post-modern era is more than just the transfer of knowledge and skills. Traditionally, teachers teach to learn in much the same way as they learn to teach. The post-modern view of teaching recognizes an approach in which technology will play a determining role in the conceptual, cognitive, and conative development of the learner, because the modernist approach is largely responsible to have brought about the present state of the *status quo* in our schools. Thus, the view of teaching in the information age goes far beyond the modernist approaches that promote behavioral (operant conditioning), cognitive-interactionist, and constructivist ways of learning.

Teacher education is not based on a single monolithic process, on a single construct or agenda. It is a broad-based process requiring collegial support networks and sharing of knowledge and skills in partnership with educators for the development and sharing of knowledge and skills in a changing context of expanding task demands. With the influx and ubiquity of technology in schools and classrooms, new challenges are being presented to stakeholders in teacher education with the result that paradigms of teaching and learning are fast shifting. It is seen that traditional curricula are described as 'outdated' and "antiquated" (Papert, 1999) and their continued application simply presage the futility of serving the needs of future generation of learners. Its continuance can be foreseen to perpetuate the *status quo* – a trend that transcends tolerance limits of any responsible government investing around 20 % of GDP (Mauritius National Budget, 2003-04) into the education sector and that has been dubbed as 'ailing' by most protagonists of reform.

1.9 Purposes and aims of the study

The purpose of the study is three-fold: first, to develop a model for the professional development of primary mathematics teachers that would support the upgrade of teachers' status within the life-span developmental perspective with respect to teacher growth and development. An adjunctive aim of the study would be to explore the effects of technological determinism and how it influences the operant view of learning in adults⁷. Contrary to the view that adulthood is a period of stability, life-span developmental psychologists are committed to the view that development occurs at every point of the life span, including adulthood (Morgan et al., 2000). With the massive investment in new technologies as part of the reform process, the model proposes to capitalize on the availability of computers in primary schools to outreach the large mass of practicing teachers dispersed around the nation's schools. This aspect of the investigation will involve studying the potential of using Open and Distance Learning (ODL) in continuing the professional education of teachers. The aim is to explore the substantive and instrumental roles of computer technology and the Internet in developing communities of learners within a distributed learning environment as a means of solving the problem associated with teacher professional growth and development. The notion of using Open and Distance Learning as a mode for adult learning, especially to meet teachers' learning needs, has as yet not been tried or experimented in the provision of teacher education in Mauritius. With the proximity of MIE to the location of primary schools and the infrastructural facilities of access to a unique training institution, the conventional method of access and training has been based on a mixed mode of face-to-face contact and 'distance'⁸.

The study will also address issues relating to adult learning (andragogy) and how it can be combined with distributed learning (technology) to foster deconvolution of what teachers know and what they need to learn (pedagogy) in the perspective of a re-defined (or re-designed) teacher education program. In brief, this research will investigate a technological-andragogical-pedagogical solution to the problem facing some of the foreshadowed problems of the Mauritian education.

⁷ Piaget identified stage level development to the formal operational stage in adolescence, but he did note that beyond that stage reasoning may operate differently in adults.

⁸ The reference to the word 'distance' has been more of a misnomer in the sense that the term has led to the setting up of a Distance Education Unit at the MIE whose task is primarily to manage student records, develop 'distance' materials, and facilitate face-to-face sessions between instructors and teachers.

This study will investigate teachers' attitudes to the subject teaching formula, as envisaged in 1994, as it could be among the best of strategies that provided opportunities for teachers to improve their status. Many observers believe that its rejection was a missed opportunity for addressing many of the problematics that have beset the education system, for example low school performance, high drop-out rates, problems of teacher burnt-out, and fatigue.

Secondly, to study the relevance and nature of the two-year (three-year since 2004) initial teacher education (ITE) program in preparing general purpose teachers to teach mathematics across the primary school curriculum. In preparing for a two-year general certificate, MIE is called upon to train teachers in a range of subject areas covering the entire primary school curriculum. In the researcher's view, this theme has been given insufficient attention. This may due to the absence of a well-established, authoritative body to ensure benchmarking and standards in teacher education programs. It is felt that in the absence of a national curriculum framework and the lack of central guidance in curriculum affairs, the focus of a single, unique training institution is ostensibly concerned with granting a nationally acceptable certificate of competence for teaching in the nation's schools. This is viewed as a deficiency in national planning strategies and lack of vision that partly account for the number of criticisms leveled against newly trained teachers – that they are superficial, lack precise knowledge in particular areas of fundamental importance, and that their knowledge is too theoretical (Willey & Maddison, 1971). The study aims at investigating the extent to which the ITE programs prepare teachers professionally and academically for a teaching career that spans a 30-40 year career cycle.

Thirdly, to analyze the structure and content of elementary school mathematics curriculum from the cognitive developmental perspective within the Piagetian tradition to determine how it influences the learning process among children. Although the study grew out of a concern for low performance, high dropouts, and high failure rates (40 per cent) at the Certificate of Primary Education, the study aims at analyzing the structure of the mathematics curriculum with a view to determining the nature of mathematics instruction and their effects on the cognitive development of children.

Although the study is set against a background of teacher discontent and failing standards in schools, it seeks to resolve a long standing cumulative problem of teacher 'neglect.' The study aims at investigating the flexibility of distributed learning as a tool for teacher development and

as a means to reach the teacher population for sustained and on-going development in primary schools. It is felt that proper design and application of technology would obviate the need for teachers to miss classes or leave their workplace to attend workshops or lectures. The emphasis on teacher development is that it is an indicator of student performance and the process can influence overall quality of education in schools. These two aspects, that is teacher development and student performance, complement each other from the point of view of the theory of adult learning. Adult learners carry to their practice experiences and resources that they find to be interestingly new and relevant to the task demands (Knowles, 1980).

These factors and the emergence of digital technologies have initially influenced the conceptualization of this research. As the study develops and the current reform process gets underway, innovative practices in the form of technology integration into pre-service and in-service teacher education, and primary mathematics curriculum reform.

Teachers' demands have been strongly assertive in claiming for recognition and upgrade of their professional status. Incidental to this claim has been the lack of provision for the professional development of teachers. There is growing realization among educationalists and policy-makers that upgrading teacher status is a long over-due prerogative, which may have been constrained for economic and financial reasons. However, a plan of action for professional development of teachers within the framework of the current educational reform taking place in Mauritius, is a national contingency.

Despite the plethora of books, journals and research on adult learning, we are far from developing a normative view of teachers' learning. The study takes into account the age factor of teachers; most are in the age group 30-50 years and awaiting to make a 'come-back' to their former teacher training institute in the hope of upgrading their status through in-service programs; a measure that will offer teachers additional salary increments, better promotion prospects, and eventually reform classroom practice.

The study also aims to show that professional development of teachers is an essential factor in improving performance in schools. Professional development can be viewed as a bridge between where teachers are now and where they need to be to meet the new challenges of guiding all students to higher standards of learning and achievement in the 21st century and beyond (Ellison, 2001). From a co-constructivist perspective, it benefits not only teachers but is based on a whole-

school development framework. By making teachers the central focus in professional development activities, it exemplifies the best available research and practice in the area of teaching and educational team building, enabling teachers, students, administrators and all other stakeholders to develop expertise and innovation in instructional strategies, developing coherent and systemic long term plans that view professional development activities as essential to the improvement of teaching and learning. Such activities also necessitate provision of resources to enable educators to develop their own individual activities.

The study also aims to show that professional development activities instruct and guide teachers to become researchers. Teachers conduct their own classroom research⁹, reflect on their own teaching methods and behaviors, identify and implement effective classroom practices, and become sensitive to the assets that students bring into the classroom (Ellison, 2001). Along with the issue of continuing professional development (CPD) of teachers, the study will also touch the problems related to inequality and social divide engendered by private tuition and other factors.

1.10 Operational definition of terms

In essence, the operational definition of a term enables the researcher to identify similarities and differences in research studies on the same topic or issue. Owing to the varied connotations that have been adopted in developed and in developing countries, it is essential to define the terms used in this study. Other terms that require clarifications are explained as and when they appear in the study.

Professional development in the study means attempts at developing teachers professionally beyond their initial teacher education programs through professional upgrade programs offered as in-service education provided the Mauritius Institute of Education.

Initial teacher education (ITE) refers to the two-year initial teacher training program offered to trainee teachers as pre-service preparation course.

⁹ Also referred to as practitioner initiated research or action research.

Primary mathematics teachers refer to the category of general purpose teachers, who teach English, French, mathematics, and environmental studies from Standard 1 to Standard VI in the primary schools of Mauritius.

Certificate of Primary Education (CPE) is the primary school leaving certificate offered to children at the end of six-year schooling and who pass the written examinations in English, French, Mathematics, Environmental Studies, and an oriental language.

Primary mathematics curriculum refers to the teaching and learning of elementary mathematics across the primary schools of Mauritius. The school curriculum also includes the way the school is organized, the timetable, and the subjects taught.

1.11 Questions for research

The range of issues raised in this chapter suggests the need for formulating research questions in order to bring more focus to the study. The research questions also serve as guide to the review of the literature, the formulation of a conceptual framework, and the choice of methodology.

There are three main research questions and a set of sub-questions as follows:

Key question

RQ 1. What model of professional development of teachers would bring about change in performance and overall improvement in schools in Mauritius?

Sub-questions

RQ 1.1. Is professional development of teachers linked to the quality of education and the reform of curriculum?

RQ 1.2. Is the 'subject teaching' formula (of 1994) a viable alternative to resolve teachers' pressures in terms of cognitive overload, classroom fatigue, and to bring about change in performance, through subject specialization, in schools

RQ 1.3. How important is Information and Communications Technology (ICT) and distance learning in the professional development of teachers within the process of an educational reform that has a vision to lead a nation into the information age?

Key question

- RQ 2. How does a two-year teacher training program suffice to prepare teachers for a teaching career that spans 30–40 years?

Sub-questions

- RQ 2.1 In what ways are failing standards in schools linked to the ITE program of the MIE?
- RQ 2.2 To what extent is the quality of education received by children dependent on the quality of training received by teachers?
- RQ 2.3 Does the present form of the ITE preparation program prepare future teachers to be reflective practitioners, use inquiry-based and constructivist approaches in teaching?

Key question

- RQ 3. Is there a need to reform the primary mathematics curriculum to meet the needs of a new breed of learners in an environment strongly influenced by technology?

Sub-questions

- RQ 3.1 What impact does curriculum reform in mathematics have on teacher development?
- RQ 3.2 Can the present primary mathematics curriculum be used to prepare adults of the coming information age society?
- RQ 3.3 What pedagogical orientations need to be used to re-structure primary mathematics curriculum?

1.12 Significance of the study

The researcher holds the position of Senior Lecturer and is Head of the Department of Mathematics and Computer Education at the Mauritius Institute of Education (MIE). Having served under three directors of the MIE and been closely associated with development and implementation of teacher education programs at all levels of teacher education and curriculum research, the researcher is familiar with the research terrain chosen for this study. Clearly, this research is of value since it is the first time that a study in the field of teacher education linking the primary school mathematics curriculum and the quality of education is being undertaken in Mauritius. Even the Master Plan (1991, p. 90) acknowledges that “research is the most weakly developed feature in teacher education.” Its findings may serve as basis to sensitize course developers on re-conceptualizing initial teacher education (ITE) program, between ITE and classroom practice, thus reinforcing the link between MIE and the schools.

It is expected that the outcome of this study will serve to provide a far deeper understanding of the rationale behind teacher training and professional growth. It will also help inform policy and decision-making processes in the field of educational planning and administration, specifically in areas of teacher development, the role of emerging technologies in adult learning, and overall school improvement and quality of education.

1.13 Summary

This chapter sets the context of the study, identifies the issues to be addressed, and provides a conceptual framework to guide the research. The chapter also describes the rationale for change associated with teacher professional development in the context of educational reform and highlights the need to investigate initial teacher education programs and primary mathematics curriculum from a postmodern perspective. Postmodernism is used, in this study, as a philosophical perspective that enables the researcher to question the educational agenda of the modernist times and to investigate how these have influenced performance and standards in primary schools of Mauritius.

Chapter 2

Literature review

2.1 Introduction

The previous chapter provided the background to the study with emphasis on the need for professional development of teachers in the context of failing standards in schools, the problems associated with initial teacher education (ITE), and the need for reforming primary mathematics curriculum. This chapter gives a general review of the literature on these issues and sets out to define professional development both from an adult learning theory and from a developmental perspective within a postmodernist setting interwoven with technological developments. The review will also survey different models of teacher professional development programs, investigate the learning needs of teachers in preparation programs and how these tie up with performance in schools. The review also draws upon models of mathematics reform projects to guide curriculum reform in the Mauritian context from a global perspective. To this end, the chapter will be sub-divided into three sub-sections, each dealing with the above themes, keeping in view the conceptual framework based on the research questions formulated in the previous chapter.

Section A: Professional development

2.2 The historical background

The historical trajectory of the growth of professional development in teacher education takes origin in the pioneering work of John Dewey at the beginning of the twentieth century. Dewey stands out among the first educators to promote the importance of professional development in teaching. As early as 1916, Dewey advocated the use of reflection as a means of professional development. Dewey asserted that one of the most important qualities a teacher may have is critical reflection, and that it has much more impact on the quality of schools and instruction than the transmission of teaching techniques. Dewey (1933) argued that teachers were guided in their actions and would act with foresight and planning rather than base their actions on tradition, authority, or impulse when they speculate, reason, and contemplate using open-mindedness, wholeheartedness, and responsibility. The foregoing argumentation seemingly points to teachers' speculation, reasoning, and contemplation as attributes encapsulating the characteristics of

reflection and that being based on how well these are done using ‘open-mindedness, whole-heartedness, and responsibility.’ The epistemic basis of reflection is learning from experience, reflecting on one own practice, and integrating observations into emerging theories of teaching and learning.

But professional development of an individual is a process which occurs in phases and is stimulated by a range of factors (David, 1997). Typically beginning teachers enter the profession as technical rationalist (Schön, 1983), are more concerned with subject matter knowledge (smk) and the skills of transforming that knowledge into meaningful elements of learning (Schulman, 1987). The ability to acquire this competency is the very essence of the pedagogical content knowledge (pck) required of novice teachers and the focus of teacher training programs. However, Feiman-Nemser and Buchmann (1986) argue that novice teachers do not acquire pedagogical content knowledge until they are faced with actual classroom teaching. The second phase may span a period of six to ten years to enable the novice teacher familiarize with primary school curriculum, classroom management, and other related activities. This period may be relatively dynamic, both in terms of professional growth and range of experiences and professional experimentation.

At each stage of the career span, teachers experience both personal and professional needs and expectations that influence the quality of their performance. A professional development program leads to change in the status of the teacher in a progression from novice to professional teacher status. At the time of joining the profession, teachers are completely ‘novice,’ with knowledge of subject content and the belief in their ability to be able to transfer that knowledge as their survival toolkits. In addition, teachers bring prior knowledge of the subject domains, their own models of teaching, and high expectations of learning outcomes at the time of joining initial training. Depending on whether the teacher education program can bring the necessary changes, novices carry this perspective, almost unchanged, to the classroom practice. Research has shown that teacher education programs hardly bring the desired change in teachers’ beliefs which, in most cases, remain unchanged until they face classroom problems.

2.2.1 The modernist view of professional development

Much of the current literature on professional development seems to center on a re-conceptualization of teachers’ role in planning for professional education. It begins with pre-

service activities, continues with induction into the profession, and then extends through the life of a professional career through on-going and sustained professional development endeavors (McBride & Schostak, 2004). The authors hold the view that effective educators are life-long learners, and that professional development must be an on-going process of refining skills, inquiring into practice, and developing new methods.

According to National Science Education Standards (1999), teachers are regarded as professionals responsible for their own professional development and for the maintenance of the teaching profession. In this sense, professional development for teachers is analogous to professional development of other professionals. Becoming an effective teacher is a continuous process that stretches from preservice experiences in undergraduate years to the end of a professional career. Because much of what is taught in schools has a rapidly changing knowledge base and expanding relevance to societal issues, teachers need ongoing opportunities to build their understanding and abilities. Teachers must also have opportunities to develop understanding of how students with diverse interests, abilities, and experiences make sense of ideas about what teachers do to support and guide all students. Additionally, teachers require the opportunity to study and engage in research on teaching and learning, and to share with colleagues what they have learned (National Science Education Standards, 1999, Chapter 4).

Both in the literature and in practice, professional development is considered a highly individualistic process focused on the needs, aspirations and careers of teachers, ignoring the need for institutional development (Kydd, 1999). The author argues that it is too often assumed that institutions exist by themselves and for themselves, with less consideration being given to the developmental needs of the people within them. This study assumes that individuals and institutional development are not separate and discrete but co-exist in a mutually supportive relationship, each contributing to the welfare of the other.

All too often modernist thinkers have been tempted to apply a business concept to the reform of education in the sense that education must respond to the changing needs of students and their teachers, just as business has reacted to its changing needs by implementing employee training (Cook, 1997). However, Townsend (1997, p. 5) argues that "business has not been uniformly successful, even in surviving. Of the top 100 firms on the business magazine Fortune list of 1970, one third had gone out of business by 1990. Are we to accept the possibility that one third of our schools will not be in existence in twenty years time?"

Business survival is invariably pitched on market success of its goods and services, whereas an educational system thrives on its capacity to cope with the changing needs of future learners (at least a generation ahead) and of setting up a perfect school and community symbiosis. Schools cannot operate in isolation from the community it is intended to serve.

2.2.2 Adult learning – the cognitive developmental perspective

The cognitive development tradition has important implications in adult learning. Viewed as a developmental phase from the perspective of the psychological model¹, professional development education may be conceptualized as a natural extension of “Piaget’s stages of cognitive development which terminated in adolescence” (Kolb, 1984, p. 14). Piaget postulated continuing cognitive development through adulthood (Oja, 1992). This new conception in adult learning represents higher stages of development and poses developmental challenges to schools and training institutions that recognize that learning and development are life-long processes.

The meaning ascribed to professional development is an on-going debate in teacher education. Researchers have tended to use the term in three overlapping senses. On the one hand, the term is used to describe the preparation and career-long development of teachers for effective practice in improving quality of education. The second type of professional development is associated with reform in education and connotes a performance indicator for effective classroom practice and successful educational reform. The third meaning relates to the conceptualization of professional development of teachers in the context of technology integration in the school curriculum, an issue with a contrasting antinomy – whether technology at the service of professional development of teachers or whether technology as a tool to support learning in classrooms. In the context of this study professional development is meant to achieve all these goals while trying to improve teachers’ status.

Many researchers consider staff development as professional development. This approach to staff development has connotations for development of staff of an institution, both academic and non-academic. In the Mauritian context, however, professional development embraces personal development as well as professional growth and is *de facto* linked to changes in the professional status of teachers. Most teachers perceive these attributes to be closely interwoven with programs

¹ see Appendix 2

that are expected to compensate teachers with prospects for career development and promotion. Additionally, such programs aim to update teachers' knowledge of, understanding of, and expertise in their professional work, through didactic presentations and activities designed to attain these goals.

2.2.3 The age theory perspective of professional development

Oja (1992) relates age theories and phases of beginning teachers' career and their professional development to patterns of life cycles. The initial phase in the life cycle coincides with the professional maturation in the behavioral, cognitive and moral development levels. Each level of the developmental span has an underlying pattern of thought and problem-solving which play a central role in determining the teacher's approach to the world of education. Additionally, each phase in a teacher's career cycle needs incentives as well as support systems to foster growth, for each phase is influenced by a complex set of environmental factors and the major characteristics of each career cycle: induction, competency building, enthusiasm and growth, career frustration, inability, wind-down, and exit (Oja, 1992).

As adults in their 20s, they are concerned with their initial commitment to teaching, curriculum planning and instruction, student evaluation, classroom management, living arrangements and setting up relationships. Age theories also suggest that adult learners are confronted with a pattern of tasks throughout their career life cycles. In subsequent life-cycle periods such as their 40s, teachers may question their priorities and values as they understand better the reality of life's challenges (Oja, 1992). Professional development viewed from a paradigmatic standpoint falls within the 'ultimate-proximate' continuum with teacher effectiveness (e.g., teacher performance, teacher career success and achievement) as the ultimate criteria of professional development, and educator characteristics (e.g., educator knowledge, educator toolkits, educator intelligence) as the proximate criteria.

2.3 What is professional development?

Perry and Ball (1996, p.1) describe "professional development is that which teachers engage in to extend their competencies and skills with the intended aim of being a more effective teacher." The expressions 'professional development' and 'staff development' are often used interchangeably. To distinguish between staff development as training and staff development as continuing professional education, O'Sullivan *et al.* (1999, p. 185) define a training need as "a

gap between the knowledge, skills and attitudes required in a job, and the knowledge, skills and attitudes of the person carrying out the job.” The expression ‘staff development’ carries a dual meaning: it relates to the development of an individual teacher as a member of staff of a school, and also to the development in some way of the whole staff of a school. The thesaurus of Educational Resources Information Center (ERIC) defines professional development as “activities to enhance professional career growth.” These activities typically refer to (i) individual development (i.e. growth or maturation in individuals due to learning, or experience); (ii) continuing education, (i.e. education of adults in professional fields for occupational updating and improvement -- usually consists of short-term, intensive, specialized learning experiences often categorized by general field of specialization); (iii) in-service education - courses or programs designed to provide employee/staff growth in job-related competencies or skills, often sponsored by employers, usually at the professional level; and experiential learning - learning by doing -- includes knowledge and skills acquired outside of book/lecture learning situations through work, play, and other life experiences

O’Sullivan *et al.* (1999) broadens the definition to include the sum total of formal and informal learning experiences throughout one’s career from pre-service to retirement. However, the notion of continuing professional development is much broader. It is personal, individualistic and often unquantifiable. For professional development to have meaning in the life of a teacher, it must be embedded within the framework of her expectation – career, professional, and moral.

There is the risk of mixing between two different issues in professional development literature - the need for professional development of the practising teacher, and the need to upgrade the professional status of the teacher. The literature is replete with cases of the former occurring within a non-formal learning context while the latter takes place through the organization of formal training programs. In making this distinction, however, the researcher wishes to emphasize, on the basis of empirical evidence, that formal training programs meant to upgrade teachers’ status do not fully cater for the professional needs of the practitioner. Such programs very unlikely respond to the authentic need of the practitioner who expresses a desire to be ‘re-fuelled’ with new techniques within the framework of a formal program to upgrade his status and to learn about new developments in theoretical pedagogy. To resort to an analogy that fits this description of professional development is to compare it to the task of refueling a plane in mid-air to keep it ‘airborne.’

2.3.1 The epistemology of professional development

Borrowing from Ströhm-Kitchener (cited in Bradbury, 1999), the three-tier model of cognition provides an analytic framework through which to examine teachers' professional growth. Ströhm-Kitchener defines three levels of cognition to explicate the epistemological underpinnings of professional growth of teachers: first-level, meta-level, and epistemic cognition. First-level cognition effectively addresses beginning teachers' engagement with content-specific demands of particular tasks. This level of cognition includes cognitive operations that engage the teacher in developing content knowledge proficiency, particularly in relation with the kind of work that constitute the teaching profession. However, effective engagement at this level cannot be isolated from the effects of processes at the meta-level. At the meta-level cognition, the engagement is more on the processes of improvising pedagogical structures to provide clear insights into the meaning and methods of the content and the substance. The processes are characterized by the heuristic method of improvisation, an outcome of experiential learning (Kolb, 1984) and the meta-cognitive dimension of the engagement in pedagogy, that culminate over years of practice to a point where the teacher engages in epistemic cognition through the intervention of professional development programs. The epistemic demands of cognition at the beginning of professional development programs requires a temporary disengagement or 'detachment' with content and pedagogy developed at the first two levels, based on the assumption that teachers are generally confident with the content-specific demands of particular tasks.

2.3.2 Professional development and professional development schools

Professional development of teachers is a fairly old concept dating back to the late nineteenth century when professional development schools existed in the American educational system. The concept of teacher training was embedded within the notion of the professional development schools. "The professional development school is defined as a school setting focused on the professional development of teachers and the development of pedagogy" (Sparks & Loucks-Horsley, 1992, p. 251). An earlier form of professional development schools, the laboratory schools, was organized within schools of education. In the late 1960s and 1970s, professional development schools took the form of portal schools. These were located within the public school system and focused on developing and field-testing new curriculum, teacher preparation, and in-service education in public school settings. In the 1980s, such schools were labeled 'school-

college partnerships' or 'professional-practice schools' as most teachers originated from colleges of education or the public school system (Stallings & Kowalski, 1992).

Major reforms, at almost all levels of education, are presently taking place in most Western industrialized countries (Moller, 1999). According to Sparks and Loucks-Horsley (1992), professional development as conceived in the 1970s and early 1980s focused not on attitudes of teachers but on their actual practice. Most research studies in teacher education pointed to growing concern about the ineffectiveness of in-service education. The findings indicated nearly unanimous dissatisfaction with current in-service but strong consensus on the reorganization of in-service, as it was critical for school programs and practices to be improved. Several major studies and reviews conducted during the period pointed to a list of effective practice within school settings that included (a) school-based programs linked to school-wide efforts; (b) teachers as co-helpers in in-service activities; (c) emphasis on self-instruction, with differentiated training opportunities; (d) teachers taking on active roles choosing goals and activities for themselves; (e) emphasis on demonstration, supervised trials, and feedback; and (f) ongoing assistance and support available on request.

Sparks and Loucks-Horsley state that staff development is a fairly recent initiative. It came of age in the 1980s when it became the focus of countless conferences, workshops, articles, books, and research reports, with the realization that staff development was a key aspect of reforming education with focus on overall school improvement efforts. Interest in staff development started within schools with a view to improving student learning. In spite of widespread interests in staff development, much remains to be learned about the process by which staff development occurs.

2.3.3 Time dimension of teacher professional development

While making an issue of school reform and its requirement of teachers learning new roles and ways of teaching, Cook (1997, p. 1) argues that teachers face an overriding problem of finding time to accommodate activities relating to professional education in their already busy schedules. The author asserts:

“the demands posed by daily teaching and other aspects of reform continue to absorb a bulk of teacher’s energy, thought, and attention. This issue explores the vital concern of how to carve out time, opportunity, and other resources teachers need to realize the vision of educational reform. Creating professional

development opportunities that educators need in order to help all students achieve the ambitious learner goals of reform will require the support and ideas of everyone.”

Clearly, time emerges as a key factor in the provision of teachers’ professional development if it is to address all the challenges of implementing new educational standards, working with diverse populations, critically examining new standards being proposed, and revising curricula. The importance of allocating additional time is one of the core concerns in the implementation of plans for teachers’ professional development. While provision of extra time is deemed impractical in the present work schedules of teachers, efforts at finding alternatives to meet this crucial need is well underway in most schools. Drawing an analogy with the Saturn automobile company employees who spend 5 % (92 hours a year) of their time learning, Cook (1997, p.3) argues:

“Imagine what a training program like this would do for people trying to restructure their schools. Or, put another way, imagine trying to change things as basic as the culture of a school with a couple of days of in-service training a year and some hours stolen from class preparation periods. If it takes 600 courses (a central training group offers nearly 600 different courses) and 92 hours a year per employee to make a better automobile, it will take that and more to make better schools. And if we’re not willing to commit ourselves to that kind of effort, we are not going to get what we want.”

To promote teachers’ school-based learning for staff development, Cook (1997, p. 1) identifies six general approaches to creating time: (i) promote time outside the classroom during the school day, for example, use substitutes to free teachers to attend workshops, conferences, observe other classes (Mauritius uses this formula of ‘floating teachers’ to free teachers for other activities); (ii) refocus the purpose of existing time commitments (e.g., use faculty meetings); (iii) reschedule the school day (e.g., make adjustments in the master schedule); (iv) increase the amount of available time; (v) promote more efficient time use (e.g., make meetings more efficient, use technology); and (vi) promote teachers volunteering some of their time (e.g., create conducive conditions such as babysitting services, allocate space for teachers’ conference).

Additionally, Raywid (cited in Cook, 1997) suggests a number of practical examples for creating space for professional development: (i) use part or all of faculty, department, or team meetings for professional development; (ii) lengthen the school day for 20 minutes four days per week; use an early release on the fifth day to provide an extended period of time for professional

development (In Mauritius the 5-day school week timetable has been extended 20 minutes to accommodate extra-curricular activities as part of school reform initiatives); (iii) one morning per week, engage students in alternative activities such as community service that are supervised by parents, community members, or non-instructional staff; use this time for professional development; and (iv) provide a common scheduled lunch and planning periods for teachers working on joint periods.

Schools' schedules have often been criticized for being overloaded. While efforts are being envisaged at 'de-loading' an already overloaded schedule, extending school hours, rescheduling school day, or adopting a business concept to resolve school problems (as in the Saturn automobile company), are approaches that do not justify a credible solution to teachers' development problems. This study considers problems relating to teachers' work and cognitive overloads as fundamental issues in refocusing teachers' commitment to improving pedagogical practice.

2.3.4 The philosophical perspective

The importance of teacher professional development in the current educational reform process cannot be over-emphasized. With the recognition that teachers are the agents of change, they represent the very lynchpin of the reform process at the core of which lies teacher development. As is widely perceived in the education sector, teacher development is more than teaching prospective teachers about the 'what' and the 'how' (Eraut, 1994) to teach. Hargreaves (1995, p. 13) argues that "to understand teacher development at the turn of the millennium is to understand it in a peculiarly exhilarating and terrifying time of accelerating change, intense compression of time and space, cultural diversity, economic flexibility, technological complexity, organizational fluidity, moral and scientific uncertainty, and national insecurity." Teacher development is complex issue and must be seen from altogether different perspective to be understood. In this study, teacher development is being investigated from two perspectives: the beginning teacher entering the profession after completing the pre-service preparation program, and from the perspective of in-service teachers following continuing education programs. The emphasis is on the application of propositional knowledge, subject matter knowledge (smk) and pedagogical content knowledge (pck) in classroom instruction and choice of proper performance indicators to guide practice. Teacher preparation programs (ITE) emphasize these approaches which contribute to the knowledge-base for teaching. Yet, these approaches have been found to have

important limitations: they are inadequate to promoting the constructs of 'good practice', 'reflective practice', 'effective practice', and 'warranted' practice (Ruthven, 1998).

2.4 Models of professional development

The following sub-sections describe various models of staff/professional development, their underlying assumptions and theoretical underpinnings as well as identifying the organizational context within which these models operate.

2.4.1 The individually guided staff development model

As the name suggests, this model of staff development prioritizes self-direction and self-initiated learning so that teachers learn many things on their own (Sparks & Loucks-Horsley, 1992). The model assumes that teachers determine their own goals and select activities that will result in the achievement of those goals. The following dictum from a New York advertisement brings more sense to the model: "At 30, 50, or 70, you are more self-educable than you were at 20" (Sparks & Loucks-Horsley, 1992, p. 235). Thus, adults learn most efficiently when they initiate and plan their learning activities, when they select their own learning goals based on personnel assessment of their needs. The model further legitimizes Knowles' (1980) adult learning theory, which postulates that adults become increasingly self-directed, and their readiness to learn is stimulated by real-life tasks and problems. Levine (cited Sparks & Loucks-Horsley, 1992) argues, from a developmental stage perspective, that individuals in different stages of development have different personal and professional needs. In this respect, individually guided staff development consists of several phases: (a) identification of a need or interest, (b) development of a plan to meet the need or interest, (c) learning activities, and (d) assessment to determine whether the learning meets the identified need or interest.

Individually guided staff development can take many forms, e.g., a teacher's reading of a journal article on a topic of interest or doing library research to determine what the experts have to say about a particular question. Similarly, a teacher might attend a workshop or conference relating to her subject area or an instructional concern. Other forms of the model relate to teachers' designing and carrying out special professional projects supported by incentive grants. These projects could involve research, curriculum development, or learning activities that empower

teachers to address their own problems, create a sense of professionalism, and provide intellectual stimulation (Sparks & Loucks-Horsley, 1992).

It is worth mentioning that, in developing countries, contrary to what the model advocates, not only teachers have no access to professional publications, but schools do not provide budgets for acquisition of journals of interest or funds for attending workshops. These factors bear heavily on activities related to teacher development and are largely responsible for stereotyped teaching in most schools.

2.4.2 The observation/assessment model

This model assumes that teaching can objectively be observed and analyzed by an observer in the classroom and improvement in classroom practice can result from feedback on the performance of the teacher. The observer objectively observes and evaluates the teacher in action, and provides helpful feedback to the teacher. The observer may be a colleague (usually a public school inspector in the context of Mauritius) who also benefits from this experience by observing another colleague, preparing feedback, and discussing the common experience. According to Wise and Darling-Hammond (cited in Sparks & Loucks-Horsley, 1992), in the minds of many teachers, the observation/assessment model is associated with evaluation, and because the process has often not been perceived as helpful, teachers have difficulty understanding the value of this model. An underlying assumption of the model is that reflection and analysis have a central role in teacher development and that observation and assessment of instruction provide teachers with data that can be reflected upon and analyzed for the purpose of improving student learning. Another assumption of the model rests on the fact that reflection by an individual on his or her own practice can be enhanced by another's observation. The approach is predicated on the assumption that teaching being an isolated profession, teachers are not able to benefit from the observations of others. "Having 'another set of eyes' gives a teacher a different view of how he or she is performing with students" (Sparks & Loucks-Horsley, 1992, p.237).

An important aspect of the model is the provision of feedback conferences based on an organization of teachers according to their cognitive levels. Glickman's (1986, quoted in Sparks & Loucks-Horsley, 1992, p. 238) work suggests that "teachers with a 'low-abstract' cognitive style should receive directive conferences (problem identification and solution come primarily from the coach or supervisor); 'moderate-abstract' teachers should receive collaborative conferences (an exchange of perceptions about problems and a negotiated solution); and 'high-

abstract' teachers should receive a nondirective approach (coach or supervisor helping the teacher clarify problems and choose a course of action)."

Though the criteria for organizing and identifying teachers according to cognitive levels appear less obvious, it is more important to provide feedback conferences in order to share experiences and, in the process, bring teachers together from their isolation. The process of organizing teachers with different cognitive levels into separate groups do not promote the professional cohesion much needed in developing a 'community of practice' among teachers. The process of 'balkanizing' teachers into ability groupings discourages exchange and sharing of experiences and do not prove to be beneficial to participants.

2.4.3 The development/improvement process model

This model of teacher professional development takes place at the school by a process of engaging teachers in activities related to systematic school-improvement efforts and having as goal the improvement of classroom instruction and/or curriculum. Teachers are often asked to develop or adapt curriculum, design programs, or solve a problem, and their successful completion might require teachers acquire specific knowledge or skills (e.g., curriculum planning, research on effective teaching, group problem-solving skills). This knowledge or skills could be acquired through reading, discussion, observation, training, and/or trial and error (Sparks & Loucks-Horsley, 1992). The model associates teachers' involvement with activities related to school improvement efforts through, for example, curriculum development, framing problems and designing solutions, and leads to alterations of attitudes or acquisition of skills.

The model assumes that (i) "mere involvement in these processes nurtures teachers' growth" (Sparks & Loucks-Horsley, 1992, p. 239); (ii) adults learn most effectively when they have a need to know or a problem to solve (Knowles, 1980); (iii) people working closest to the job best understand what is required to improve their performance; and (iv) that teachers acquire important knowledge and skills through involvement in school-improvement or curriculum-development processes.

2.4.4 The training model

According to Sparks and Loucks-Horsley (1992), the training model of staff development is conducted with a clear set of objectives or learner outcomes focused on knowledge and skills

development. In this model, training is cost effective because of the high participant-to-trainer ratio. It is conducted at a teacher training college and in collaboration with schools. Training might include exploration of theory, demonstration or modeling of skills, practice of skills under simulated conditions, feedback about performance, and coaching in the workplace. The model uses support of school teachers as peers for observation and discussion. Sparks (1983) points out that teachers value their peers as trainers because teachers can learn as much from their peers as from expert trainers. Wu's (1988, quoted in Sparks & Loucks-Horsley, 1992, p. 242) "review of research confirmed ... that when their peers are trainers, teachers feel more comfortable exchanging ideas, play a more active role in workshops, and report that they receive more practical suggestions." The training model assumes teachers can change and learn to replicate behaviors in their classroom that were not previously in their repertoire.

The training model is recognized as a powerful process for enhancing knowledge, skills, and attitudes (KSA). A point worthy to note in the implementation of this model of teacher professional development is that, unlike teacher educators, peers do not change attitudes, values, and behaviors as these are anchored in the school ethos, which differ from school to school. However, teachers have better knowledge of the school terrain and their own needs than teacher educators who are detached from the realities of school life.

2.4.5 The inquiry model

As a staff development model, the inquiry approach tends to take different forms. It can be a solitary activity, be done in small groups, or be conducted by a school faculty. Its process can be formal or informal; it can occur in a classroom or at a teacher centre or result from a university class (Sparks & Loucks-Horsley, 1992).

The individual approach to staff development is premised on the belief that teachers have the ability to formulate valid questions about their own practice and to pursue objective answers to those questions. The approach is based on the assumption that (i) teachers are intelligent, inquiring individuals with legitimate expertise and important experience; (ii) teachers are inclined to search for data to answer pressing questions and to reflect on the data to formulate solutions; and (iii) teachers develop new understandings as they contribute to and formulate their own questions and collect their own data to answer them. When performed as a group activity, the model takes the form of teachers organizing into groups to gather weekly, after school, for an hour or two at a teacher centre to examine issues of professional interests. Action research helps

teachers relate research on teaching to their unique classroom. Sparks and Loucks-Horsley (1992) advocate action research to be organized in the form of quality circles, problem-solving groups, school improvement projects, or classroom research as peer-centred options for promoting professional growth. The model views 'teachers as researchers,' a form of teacher development that helps to narrow the gap between research and practice.

Though the call for inquiry-oriented teachers is rooted in the works of Dewey, Zeichner, Schön, and Ferraro (see section 2.2.1.2), the notion of teachers organizing to meet periodically to discuss instructional or pedagogical issues as part of professional development endeavors is more easily said than done, because school schedules and teachers' workload are factors precluding such initiatives. The concept of 'teachers as researchers' is an important consideration in experiential learning (Schön, 1986) that requires teachers to inquire, reflect, and research their own practice. With the advent of the information age, teachers' roles as facilitators of learning require that they be freed from the routine of student-teacher interaction to support action research initiatives forming part of their own growth and development.

2.4.6 The inclusion model

The inclusion model of professional development assumes a holistic view of the development of the teacher from novice to the advanced (veteran) practitioner. Instead of seeing pre-service and in-service as distinct and separate stages, a holistic view of teacher development is presupposed (Dilworth & Imig, 1995). The model tends to recast the concept of in-service programs to reflect a shift from deficit-based to competency-based approaches, building on teachers' (prior) knowledge, skills, and experiences considered as assets. Professional development organized around this focus "shift(s) teachers away from dependency on external sources for the solution to their problem and towards professional growth and self-reliance in instructional decision making" (Dilworth & Imig, 1995, p. 2).

As prospective teachers become increasingly diverse in background, age, and experience, the model emphasizes practicing teachers to focus less on transfer of knowledge and strategy, and more on analytical and reflective learning. The reflective approach helps teachers sharpen their skills in problem solving, determining students' needs, and conduct action research relevant to their schools and classrooms. However, Dilworth and Imig (1995) caution providers of in-service programs that teachers have little (or no) time during the school day to pause, reflect on practice, or conduct research.

Time as a determinant in school-based teacher development emerges again as a leitmotif standing in the way to constrain efforts at teachers' professional growth. The model calls upon the use of reflective practice (keeping journals, portfolios, undertaking action research, etc.) among prospective teachers, drawing professional guidance from seasoned fellow colleagues to understand their own teaching strengths and weaknesses. The model has important implications for how schools are organized, in other words, as places for teachers to learn as well as teach. Efforts at decentralizing professional development addresses one of the most pervasive problems confronting practicing teachers – that of teachers isolation. The concept of 'learning together' may be viewed as the ideal in progressive schools, yet time as a factor still determines largely whether the ideal is pragmatic and realistic. Decentralization as a process allows more tailored professional development activities that are school-based, and the approach is increasingly being conducted in and by schools rather than colleges and universities.

This study provides evidence to support the view that teachers learn more from immersion through teaching practice and classroom enactments in schools than time spent at training colleges. However, Little (1986, quoted in Dilworth & Imig, 1995, p.3) cautions that

“restructuring professional development around such concepts is easier said than done because the current system often contradicts or fails to accommodate new requirements and initiatives. Newly professional development initiatives call not only for training, but also for the adequate opportunity to learn within a teacher's day-to-day work. On the other hand, in the absence of a good fit between the nature of a reform and the nature of professional development, schools and school systems are inclined to do something, and that something is likely to look like the existing menu of training programs.”

2.4.7 The immersion and reflection model

Sprinthall and Sprinthall (cited in McKenzie, 1991) propose a model of staff development that promotes the developmental growth of teachers through a blend of immersion and reflection. “This model stresses the importance of role-taking experiences (learning through active involvement in real situations), an appropriate match of teacher levels of development with experiences and leaders, careful and continuous guided reflection, a balance between action and reflection, extension of the program over a significant period of time (two to three years), and the provision of personal support for the learner, along with a reasonable level of challenge” (McKenzie, 1991, p.3).

The emphasis on role-taking experiences, guided reflection, and provision of personal support imply that teachers should have ample opportunities to practice the skills in relatively controlled and safe environments until a sufficient degree confidence and 'executive control' has been acquired (Joyce & Showers, quoted in McKenzie, 1991). The approach necessitates school-based 'immersion', which allows a certain degree of 'coaching' by peers and a commitment to sustain the practice. The approach involves the recognition that teachers are adult learners with individual learning styles, different stages of development, and quite divergent interests and needs. The challenge to organizers is to provide a program that builds appropriate matches between learners and experiences (McKenzie, 1991).

2.5 The postmodernist perspective

The postmodernist perspective suggests a yet broader definition of professional development that warrants a new mindset to use technology to foster teacher growth (Grant, 1998). It is true that modernism privileged the technological hype of the previous decade that saw the commitment of corporate bodies to be engaged in the educational venture through the provision of educational software to schools, and the volition of the state to inject massively in educational technology as an economic priority. However, postmodernism provides us with a broader perspective to see how technology can enhance pedagogy and, by extension, provide enhanced opportunities for individuals to improve professionally and, by ricochet, improve schools. Equally, from this perspective, professional development goes far beyond the provision of traditional teacher 'training.' It encompasses a definition that includes formal and informal means of helping teachers develop new insights into latest pedagogy and what is best practice, and explore new and advanced understandings of content and technological resources. In this sense, postmodernism has brought about the need for a fresh look at the entire locus of the educational enterprise from teacher education, school, classroom and the teacher to teaching, learning, assessment, and the curriculum.

2.5.1 Instructional technology and professional development

The dawn of the twenty-first century is witnessing the rapid growth of the Internet and the World Wide Web (WWW) into becoming "a powerful, global, interactive, dynamic, economic and democratic medium of learning and teaching at a distance" (Khan, 2000, p. 51). This development coupled with the emergence of digital media technologies and distributed learning have revolutionized the ways and means of delivering instruction to both traditional (campus-

based) and non-traditional (off-campus) students. The world wide web (WWW), interactive multimedia, and computer mediated communication (CMC) represent three streams of development in instructional technology (Inglis *et al.*, 1999) that seemingly tend to direct the way to alternative forms of delivery of content and instruction in teacher education and training. E-learning, Web-Based Learning, and distributed learning are learning models associated with technology and are meant to transform education and training.

The term e-learning is not very precise. Most often it means an approach to facilitate and enhance learning by means of personal computers, CDROMs and the Internet. This includes email (with listserv), chat discussion forums, and collaborative software. Advantages are seen in that just-in-time learning is possible, courses can be tailored to specific needs and asynchronous learning is possible. E-learning may also be used to support distance learning through the use of WANS (Wide Area Networks), and may also be considered to be a form of flexible learning. Often, but not always, e-learning attempts to be a student-centered learning solution. Some view e-learning as a means to *effective* or *efficient* learning, due to its ease of access and the pace being determined by the learner (Wikipedia).

The e-learning solution may also be regarded as an educational innovation to provide solutions to constraints relating to limited time, money, personnel, and access (Reeves & Hedberg, 2003). E-learning development initiatives have an economic focus on reducing physical links between instructors and students and sharing instructional contents over the Internet. According to Reeves and Hedberg (2003), e-learning formats include Web-based training (WBT) and Web-based learning environments (WBLE). The format prioritizes sharing of instructional materials and management of learning systems over Internets or intranets. The focus is on reducing physical links between instructors and students. Today, more and more e-learning initiatives are directed towards incorporating interactive multimedia as a cognitive tool.

E-learning is a relatively recent add-on to online learning “to describe the application of information and communications technologies (ICT) to enhance distance education, implement open learning policies, make learning activities more flexible and enable those learning activities to be distributed among many learning venues” (Inglis *et al.*, 1991, p. 1). In an etymological sense, the term e-learning connotes a broad-based catchword that encapsulates all elements of learning using digital media delivered either through interactive video or over the Internet. In this sense, it is not very precise; it relates to one

element of education. Whereas the term online education covers a much broader range of services, e-learning services are often offered by companies or corporations whose main focus is on delivering course content. According to Palloff and Pratt (1998, p. 5), a white paper posted on the website of Blackboard¹ defines online education as:

“an approach to teaching and learning that utilizes Internet technologies to communicate and collaborate in an educational context. This includes technology that supplements traditional classroom training with web-based components and learning environments where the educational process is experienced online.”

The definition suggests that there is more than a way to deliver online courses.

Traditionally, web platforms have served as communicative media for chat platforms, discussion forums, and grade books to hold publications from trivia to educational materials that are susceptible to alterations, amendments, modifications, and often having a transient presence. Web platforms are truly open and democratic platforms, freely accessible to one and all.

Another development in educational technology is the Open Distance Learning (ODL) mode of instruction. ODL is not demand-driven. Basically ODL integrates communication technologies with traditional distance learning mode of instruction. It prioritizes open and flexible learning. Technology is relatively transient and ever changing, and learners' needs are abstract and often ill structured. Development of learning systems should be driven not by the needs of technology but by the requirement of learners. Too often, these were driven by technology. However, as technologies evolve the distinction among them is getting blurred to the point we can no more speak of these as representing separate domains. It is now firmly established, especially among instructional systems developers, that the needs of learners are center stage in the development of learning systems. Open learning systems are designed around recognition of this cognitive requirement. In this study, Open and Distance Learning will be investigated as a means of targeting non-traditional adult learners, especially teachers who have been deprived (or rather denied) access to professional development opportunities.

¹ Blackboard website can be reached on: <http://www.blackboard.com/> Accessed 13 August 2004.

2.5.2 Online learning systems for professional development

Traditionally learning systems in education and training are built around integration of Skinner's behavioral constructs of stimulus and reinforcement (S-R operant conditioning), the constructs forming a loop in a learning cycle. Interaction as a construct is central to human cognition. An equally important construct to facilitate cognitive learning is that of constructivism (or in the hybridized form of social constructivism, radical constructivism, and socio-constructivist) and interaction which are embedded within the loop to form a setting that fosters changes in cognitive behaviors among learners either individually or through cooperative, collaborative and peer interaction.

In online learning environments, especially in systems where learning occurs at a distance, the learner-instructor face-to-face component fostering cognitive interaction makes way for the mediating technology to foster learner-interface interaction. Successful interaction as a variable of the system is dependent on other theoretical constructs. McIsaac *et al.* (1999) propose four such constructs that are of particular interest to distance learning in computer-mediated communication² (CMC) environments. These constructs (namely, transactional distance, interaction, learner control, and social context of learning) are intricately related to five other components of distributed learning system: learners, peers, instructors, content, and technology (see Figure 1).

² CMC facilitates online discussion, exchange and provision of information. Though originally text-based, such communications now integrate multimedia components of sound, video and graphics

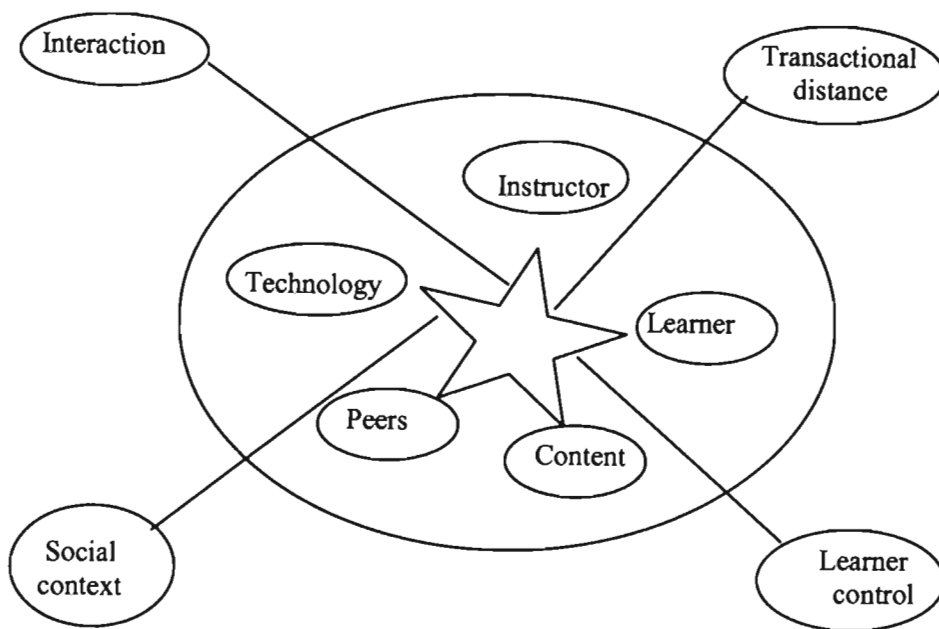


Figure 1. Adapted from McIsaac *et al.* (1999) showing relationship between cognitive constructs and components of a computer mediated communication system.

According to McIsaac *et al.* (1999), the structure of each of these constructs set the stage for the successful or unsuccessful learning experiences for distance learners who are typically left to their own devices when interfacing instructional materials in distance mode.

Reeves *et al.* (2004) propose yet another vision to online learning: online collaborative learning. Online collaborative learning is envisioned as providing learners, enrolled in a common unit of study for training, continuing professional development, or the pursuit of an academic degree, to work together online to solve complex problems and complete authentic tasks. The authors argue that in online collaborative learning learners never meet face-to-face, yet they are highly motivated and form strong bonds that encompass productive teamwork, in-depth collaboration, and even lasting friendships. “Through intensive engagement in the collaborative solution of authentic problems, the learning outcomes accomplished by these learning will be of the highest order, including improved problem-solving abilities, enhanced communications skills, continuing intellectual curiosity and robust mental models of complex processes inherent to the performance contexts in which their new learning will be applied” (Reeves *et al.*, 2004, p. 53). The authors

caution that online courses seek to ensure that learners spend 45-50 hours of academic contact time for a traditional 3-credit-hour, semester-long course.

2.5.3 Online interaction

The construction of interaction, or the shaping of the process of interaction, is a function of instructional materials and learners targeted in an online setting. A setting with such functionality supports dyadic and group interactions for the materials interface between learner and instructor, learner and learner, learner and content, and learner and interface (Najjar, 1995). According to Najjar, learner-instructor interaction provides the background for motivation, feedback, and dialogue between the instructor and the learner, while learner-learner interaction is the exchange of information, ideas and dialogue that occur between learners. Learner-content interaction provides the knowledge and intellectual information that are gained by the learner. Learner-interface interaction refers to the dyadic interaction between the learner and the technology that delivers the instruction. The focus on learner-interface interaction is germane in terms of concerns for the inordinate amount of time learners spend on understanding the mediating technology rather than the lesson. For this reason, learner-interface interaction is considered to be a crucial element in the design of online environments. McIssac *et al.* (1999) observe that because online discussion is primarily text-based, online environments offer the opportunity to think, write, and review before sending comments to others. The main concern resides in the fact that learners need a certain level of technical sophistication to be able to use the technology effectively.

The process of dyadic interaction in online learning environment is not dialogical. The transaction of interaction as conceived in such environments is different when compared to interaction between two interlocutors who jointly develop meaning through a series of exchanges. From an ontological perspective, interaction is an exchange of meaning; there is no exchange of this sort in online environments. The human-computer interface (HCI) limits the act of interaction into a one-sided flow of meaning between the learner and the interface. This one directional flow of the exchange is attributed to the lack of communicative synchrony (Fontana, 1995) characteristics of non-verbal signals in dyadic interaction. It contributes to a loss of the conversational context in the construction of meaning. A lack of communicative synchrony coupled with a lack of immediate feedback influence the behaviorist mode of learning, resulting in feelings of isolation, uncertainty and often a sense of being lost in cyberspace experienced by learners in environments supported by communication technologies.

Internet activities have been divided into three overlapping categories: electronic mail (with listserv³), World Wide Web, and discussion groups. Electronic mail is asynchronous, non-interactive communication, and non-interacting; World Wide Web is non-interactive, web surfing; and discussion groups can be synchronous or asynchronous. Non-interactivity being an integral feature of communication technology, as is exemplified in distance education delivery modes, efforts of instructional designers are directed toward the integration of behavioral constructs into online learning environments. Reeves and Hedberg (2003, p. 5) claim that:

“the essence of what makes a learning system interactive is the task in which the learner is engaged.... Forms and levels of interactivity are influenced by many aspects of the design of interactive learning systems, but none is more important than the task the learner is trying to accomplish or the problem he or she is trying to solve.”

This relativism in the concept of interactivity is further emphasized in the design of web-driven learning systems where interactivity as a process is achieved through sharing instructional materials and the ensuing dialogue between learners in ‘a community of practice.’

Online learning environments have another dimension of concern about the quality of Web-based courses. Naidu (2003, cited in Reeves *et al.*, 2004, p. 54) cautions that the design of online learning must ensure the application of traditional face-to-face pedagogy rather than “be overly driven by an obsession with statement of objectives, assessment of outcomes, and a hierarchical ordering of subject matter content, as opposed to a focus on building rich resource-based learning environments around enduring themes.”

2.5.4 Authentic learning and virtual communities

Conway (1998) describes authentic learning as those activities that involve the learner in solving real-life problems or allow learners to share the product of their learning with an audience that goes beyond the teacher. Even if technology can facilitate authentic learning activities in the classroom, it is the latter aspect of knowledge sharing through collaborative activities among learners in a technologically supportive environment that promotes authentic learning. Authentic

³ Listserv is a program that maintains mailing lists, automatically receiving and sending messages to members of the list. A person who has subscribed to a listserv can mail to other members of the list by sending an e-mail message to the listserv. A listserv can also place new members on the list and remove members from a list automatically upon request.

learning may be regarded as a by-product of activities supported by technology within a community of learners.

Technology as a mediating agent in the process of learning creates its own dynamics by creating new social structures, thus making learning a social process. The new structures are the result of the social appropriation of technology that has led to the creation, in cyberspace, of various shapes of online gathering, regrouped under the common designation of virtual learning communities (Henri & Pudelko, 2003). Of the four principal types of virtual communities (namely, community of interest, goal-oriented community of interest, learning community, and community of practice), community of practice will be the main focus in this study.

A community of practice groups people forming part of a community which practice the same trade or share the same working conditions. According to Henri and Pudelko (2003, p. 483), the community of practice is characterized as follows: it emerges from collective activity, it is the result of the involvement of individuals in the actions of professional practice. The virtual community of practice represents a means of investing participants in the social or professional definition of their trade, reinforce their personal identity, enrich or perfect their daily practice and at the same time contributing to the practice of the community. The objective for a community of professionals to be involved in a virtual community of practice is to make practice explicit, to improve and even to transform it. For the organization, it is a means of perennializing practices judged desirable, to integrate new members and to maintain the common know-how essential to efficient professional practice.

For too long, learning has relied primarily on the 'transmission' (model) of information through direct and indirect teaching and assuming independent learning of the individual. "This mode is highly ineffective where students' prior learning opportunities have developed neither the epistemic assumptions appropriate for the textual construction of knowledge nor sufficient metacognitive controls for independent study" (Bradbury, 1998, p. 11). Learning with technology, especially in education and training, involves a process of construction in the development of knowledge analogous to a spiral, each stage being increasingly refined and reconstructed.

At the heart of technology lies a design process, which begins with the perception of a need, continues with the formulation of a specification, the generation of ideas and a final solution, and ends with an evaluation of the solution (Dean *et al.*, 2004). In the process learners have access to

a wealth of information, organize it, evaluate it, and then effectively express their new knowledge and ideas in new forms. They work cooperatively in a team to solve complex task that require them to use high level thinking skills (Conway, 1999). Gregoire *et al.* (1996) argue that authentic learning in conjunction with use of technology have the power to stimulate the development of intellectual skills such as reasoning and problem solving ability, learning how to learn, and creativity.

2.5.5 Web-based learning environments (WBLE) and ‘community of practice’

It is abundantly clear that colleges and universities are being encouraged to use media and technology in education to address learning problems and to cope with the increasing number of students going ‘distance’ for one reason or another. In teacher education, the overarching challenge is that educators and administrators have yet to realize that a large proportion of practicing teachers feel inadequate to respond to the demands of a new social order engendered by the current reform initiatives and the information age. As discussed previously (see section 2), a brief, one-off initial training provision is unlikely to provide teachers’ career needs for a profession for which continual upgrading is the norm. The majority of teachers feels the need for continuing professional growth opportunities and as such constitutes a potential distance learning market to which computers, the Internet and the World Wide Web (WWW) can only be instrumental in bringing about continuing, life-long learning, not just for career enhancement but for overall educational improvement.

The convergence of digital technologies of computers, the Internet, and the World Wide Web (WWW) have made possible the emergence of a new and rich learning environment, the Web-based learning environment (WBLE). As the name implies, WBLE is becoming a viable, interactive option for teaching and learning. The system can be regarded as presenting in two complimentary modes: one in-campus, for traditional students; and the other off-campus, for non-traditional students. The off-campus mode of Web-based learning environments (WBLE) can be viewed as an extension of distance education or as a variant of classroom activity (Pringle, 2002). In this mode, it has become an ubiquitous open Web of interconnected, global computer networks allowing extensive interaction and collaboration among learning communities. This development has further led to the concept of building “communities of learners.” Pringle (2002, p. 218) argues that

“such communities are built on principles of coparticipation while challenging traditional modes of teacher-student relationship. Here, coparticipation implies the presence of a shared language that becomes accessed by all as they engage in the activities of the community with a goal of facilitating meaningful learning. In effect, the teachers are no longer the bearers of information, but partners in conversation that seek to construct knowledge. This construction occurs through negotiation and consensus building, allowing the viability of such knowledge to be tested against what has been established and accepted as ‘truth’.”

An understanding of the different operating modes implicit in Web-based learning environments (WBLE) serves as guide in designing appropriate delivery mechanisms for continuing education of adult learners constituting a ‘community of practice.’ Dabbagh (1994) identifies three modes of Web-based learning (WBL) in the ‘in-campus’ category: the *adjunct mode*, the *mixed mode*, and the *online mode*. Each mode identifies a distinct structure and mechanism within a specific setting for delivery of instructional materials electronically. In the *adjunct mode*, classroom instruction is enhanced with materials from the Web. The Web-based materials represent an add-on component to support instruction. From an educator’s point of view, Web-supplemented facilitation suits beginning teachers most in the process of globalizing teacher preparation curricula by providing opportunities for synthesizing course content with instructional materials from the World Wide Web (WWW). The WWW abounds with information on instructional materials and content to the extent that a single yahoo.com search (27 May 2004) for ‘tessellation’ yielded as many as 76,800 hits.

The *mixed mode* combines both face-to-face and Web-based instruction, with the latter comprising almost one half of the course conducted online. In this mode, networking is fully integrated into the curriculum and course delivery builds dependency on the Web. This mode is mostly demand-driven and is campus-based.

Dabbagh (2000, p. 38) describes “the online mode ... is a combination in which the network serves as the primary environment for course discussions, assignments, and interactions even though media such as textbooks, telephones, or face-to-face meetings may be incorporated as part of the overall instructional design of the course.” Each of these applications of Web-based learning (WBL) incorporates hypertext, hypermedia, graphics, animation, digital video and audio, self-contained interactive modules, and asynchronous and synchronous tools.

2.6 Distributed learning

According to Bowman (1999), the distributed learning option combines traditional classroom-based courses with traditional distance learning courses. An extension of the distributed learning option offers an approach to create wholly virtual classes. Distributed learning initiatives are directed towards sharing instructional content over Internet or across various intranets.

Distributed learning formats have potential for professional development initiatives in flexible delivery, flexible learning, and open learning, all of which reflect the convergence of various instructional technologies. The format is technology-based and therefore technology-driven. Its outreach capability is, in essence, learner-centered and designed to reach learners separated in time and space. It engages learners in a process that emphasizes learning itself, beyond classrooms, instead of the technology used. It entails a certain degree of learner control over when, where or what to learn in order to make learning meaningful. However, in the process of distributed learning occurring through computer interfaces, with the mediation of Web-based technology, human computer interaction becomes the dominant learning paradigm. In this perspective, learning is contextualized under the umbrella concept of e-learning (see Appendix 4), the model being inherently an application of new technologies to distance education, as it offers all the ingredients of distance learning online. "What WBL offers that is unique ... is the learning environment in which texts, pictures, video and audio are integrated into one system, access to huge databases is simple and easy, and more flexible interactions – especially asynchronous learner-learner interaction – are far simpler than before" (Jung, 2001, p. 526).

2.6.1 Open and Distance Learning (ODL)

Open and distance learning is also an e-learning solution that falls within a distributed learning format, with focus on the concept of sharing instructional materials over the Internet (or intranet) and participation of learners in the development of content and knowledge. The distributed learning option operates under a variety of modes, combining traditional classroom-based courses with distance learning courses. An aspect that has enormous potential for adult learning is in its capacity to create wholly campus-based virtual classrooms over intranets⁴ or off-campus

⁴ A prominent example of a campus-based On-line Distance Learning (ODL) system is the Open Learning System (OLS) developed at the Centre for Information Technology in Higher Education (ITeD), Faculty of Human Sciences, University of KwaZulu-Natal, Durban. Though campus-based and centrally located at the

communities of learners over the Internet. In this study, the idea of an Open Distance Learning system is to share content and instructional materials among widely dispersed practicing teachers having a common interest of enhancing professional growth with campus-based instructors. The aim is to bring home to co-learners curriculum materials which would otherwise be inaccessible. In this sense, ODL systems are not rated as market products to be commercialized with faculties or institutions. The essence of its success lies in the degree of co-participation and intersubjectivity (see section 3.12.1) in bringing change to teachers' self-efficacy and in reforming practice.

2.6.2 Intersubjectivity

Another component of knowledge facilitation in on-line distance learning environments is the concept of intersubjectivity between instructors and learners and among peers. At its most basic, intersubjectivity is to do with

“shared understanding that helps us relate one situation to another. Instructionally, it implies that students (learners) and instructors each have attendant responsibilities; students are tasked with discovering how to build knowledge and manage their learning, and instructors with guiding students in these processes” (Bober & Dennen, 2001, p. 241).

The immanent nature of intersubjectivity engages learners and instructors into developing attendant responsibilities within online learning environments and is fundamental to the notion of teachers' knowledge being a shared entity. Such systems engage learners to be tasked into discovering how to build knowledge and manage their learning, and instructors in guiding learners in these processes. It also provides a framework for building shared knowledge with online communities in settings around the following themes: communication, interface design and its impact on intersubjectivity, and communicative aspect of asynchronous and synchronous discussions (Bober & Dennen, 2001).

Durban campus, the OLS is accessible to registered (off-campus) distance and overseas students. Its main features comprise in-built chat capabilities, discussion forums, and has the potential for multimedia courseware authoring.

Section B: Teacher preparation programs

2.7 The research dimension of teacher preparation programs

Many teacher education programs favour student teachers to read and follow research findings as a major priority in their preparation (Gitlin *et al.*, 1999). Such programs advocate teachers to assess research as well as become researchers by participating in some form of action research, a practice that is becoming central to teacher development. Tom (1985) argues that a common feature of teacher preparation is the desire to expand research beyond its traditional fact-finding mission, thereby enabling pre-service and in-service teachers to become critical consumers of research and/or engage in practitioner initiated enquiry. Programs that engage teachers in a variety of activities, including becoming critical consumers of research, require participation in action research and generally lead to a reflective approach to decision making.

The goals of research in education have expanded beyond its fact-finding mission (Oja, 1992). Its epistemological underpinning favours a process of reflective inquiry that informs educators of the rationale for a 'paradigm shift' that is central to teacher change. Oja (1992) goes as far as arguing that throughout their careers, teachers are expected to learn about their own profession by studying the findings of those who are not themselves school-based teachers:

Gitlin *et al.* (1999, p. 2) further argue that research should not only go to practitioners but that the focus of teacher education programs is to get practitioners engage in research, "thereby enabling pre-service teachers to become consumers." Consumption of research and/or engaging in research enable practitioners to transform their approach to classroom practice. They rely more on the knowledge from research and the knowledge from consumption of research. These inclusive approaches make teachers more confident to develop inclusive pedagogy, use reflective thinking in their practice than the prescriptions from their methodology courses in the face-to-face mode.

The relationship between research in elementary mathematics education and instructional practice is an area of concern in teacher preparation. Romberg and Carpenter (1986) argue that most research on teaching (mathematics) have focused on enhancing traditional mathematics teaching by making it more efficient and effective. Many prospective elementary school teachers believe

that mathematics is only about numbers and procedures and that teaching is telling or showing students what to do (Schuck, 1998).

2.7.1 The dimension of reflection in teacher preparation programs

Reflection has become one of the most popular issues in education (Copeland *et al.*, 1993). As early as 1904, John Dewey advocated the development of reflective thinking in teacher preparation, especially at the pre-service level. Dewey contends that the primary purpose of teacher education programs should be to help pre-service teachers reflect on problems of practice and argued that teachers lacking an inquiring mind will have their professional growth curtailed even if they are proficient in the skills of teaching. Dewey further argues that lack of reflective thinking leads to intellectual dependency and those teachers need to be helped to develop habits of reflection in order to address problems in education (Mewborn, 1999).

LaBoskey (1993), on the other hand, argues that there is a lack of consensus about what constitutes reflective thinking. There is little agreement on its content or on the nature of the contexts that promotes it. LaBoskey (1993) cautions that there is little shared meaning among educationalist writing about reflective teaching. The author further argues that the focus on reflective thinking as it applies to teaching is on recognizing that teaching is problematic. While Doyle's (1990) studies in teacher education seem to accord with the general view that the knowledge base for reflective thinking includes prior knowledge (personal experience and beliefs), craft knowledge (teaching skills), and propositional knowledge (research and theory of education), LaBoskey (1993) posits that all teachers engage in some form of enquiry, although not all enquiries result in significant changes in thinking and practice.

It is widely believed that the concept of reflection and reflective practice can lead to new insights or perspectives in problematic situations (LaBoskey, 1993). Just as there are many different conceptions of what the "reflective thinking" actually involves, there are also different views of how it can best be achieved through teacher programs. The debate in teacher education relates to the form of reflective thinking that can be incorporated with the pedagogical training teachers should receive.

According to Schulman (1986, p. 9), the pedagogical preparation of teachers can be seen as involving the development of three different forms of knowledge. First, there is content

knowledge which involves “going beyond the facts or concepts of a domain. It requires understanding the structure of the subject matter.” Secondly, there is pedagogical content knowledge: “The particular form of content knowledge that embodies aspects of knowledge more germane to its teachability.” Finally, there is curriculum knowledge which involves the full range of curricular activities available for teaching a particular topic.

2.7.2 The constructivist dimension of teacher preparation

The role of constructivism in contemporary education has been at the center of most educational debates surrounding the problem of reforming classroom instruction. Constructivist view of learning is based on students’ active participation in constructing knowledge for their own rather than store verbatim information gathered from teachers, textbooks, peers, and the surrounding environment. Dewey (1938) contends that there can be no intellectual growth without some reconstruction, some reworking. Constructivist learning is based on the learner’s active participation in problem solving and critical thinking in a form of learning activity which is relevant and engaging. The author views learners as constructing and reconstructing their own knowledge by testing ideas and approaches based on their prior knowledge and experience, applying these to a new situation, and integrating the new knowledge gained with pre-existing intellectual constructs. The nature of this construction depends on the individual’s prior and existing knowledge. While learning may be individually or socially constructed, constructivism makes the learner’s knowledge her own.

Bruner (1966) provides a general framework for instruction based on the study of cognitive structures (e.g. schema, mental models). The learner selects and transforms information to reach pre-set goals. For example, the learner knows the meaning of a triangular number and yet can visualize it (mental model) as a set of dots arranged as a right-angled triangle. Bruner’s own experiment with prime numbers, which were modeled with beans arranged as sets of incomplete rows and columns, emphasizes the cognitive dimension of the constructivist theory. This approach to learning provides meaning to experiences and allows individuals to “go beyond the information given” (p. 6).

Cognitive constructivism as advocated by Piaget has roots in genetic epistemology linked to child development research. The theory proposes that humans must construct their own knowledge which they do through experience, and experience enables them to create schema and mental

models. Piaget helps us to understand that meaning is constructed as children interact in meaningful ways with the world around them. The theory emphasizes that students must be given opportunities to construct knowledge through their own experience. There is less emphasis on the teacher, much less on development of specific skills, and more emphasis on learning in a meaningful context. This model of the Piagetian classroom lends itself more favorable to the promotion of educational technology which provides a learning environment that helps expand the conceptual and experiential background of the learner. However, learning without direction and goals as in the Piagetian setting is not learning as a way of doing things but doing things without an element of learning. Papert (1999) dubbed this type of constructivist approach to learning as “dirty” learning. It is emotional, complex and intertwined with the learner’s social, cultural and cognitive context, more specifically when compared to behavioral approaches.

The foregoing lines of argumentation have juxtaposed knowledge and constructivism on the basis of the fact that knowledge is socially mediated and individually constructed during the teaching-learning process. This premise lends itself to the view that the focus on the learner is not the subject matter to be taught but rather on the learner thinking about how to learn (Hein, 1991). If we are to accept this view of epistemology as conceived by constructivist theory, then do we reject the Platonic and all subsequent views of epistemology as advocated by Aristotle and other realist thinkers (e.g. the Socratic question posing)? The Platonic school held that knowledge is ‘out there’ independent of the knower, while the Aristotelians view knowledge as being constructed by the senses of an individual (Dunlap, 2001). These differing views of epistemology make sense to educators, because in our profession (teacher education), our epistemological views dictate our pedagogic views (Hein, 1991).

If knowledge consists of learning about the real world ‘out there’, then as educators our tasks would simply consist of understanding that real world, organize it in the most rational way independent of the learner, and present it to our learners. These tallies with the fact that educating teachers is a form of social mediation, where we, as educators, construct meaning for the learner who sees the world as being structured and construed from our viewpoint. Do learners construct their own world or do we channel them into constructing the world the way we see and structure the world? These opposing dialectical views form the basis of the constructivist position which requires us to follow a pedagogy which argues that we must provide learners with the opportunity to: a) interact with sensory data, and b) construct their own world (Hein, 1991). Teachers act as mediators to favor the epistemic engagement in the preparatory phases of an occupational career.

The dialectical relationship between constructivist theory and the epistemology of teachers' learning depends partly on the perceived self-efficacy⁵ of how well they develop the basic cognitive, self-management and interpersonal skills on which their occupational career is founded. In the preparatory phase, they value initial teacher education (ITE) as the first step in professional certification that is believed to provide adequate preparation with state-of-the-art materials to enable the novice teacher survive in the new profession. It is on facing the reality of the classroom situation that teachers realize the inadequacies and deficiencies in their preparation programs or suspect that something has gone awry in the link between education and work. From then on, the sense of security generated by the survival strategies of the preparation programs fades to the realization of the missing link that threatens the capacity of the teacher to withstand the demands of a new career. This phenomenon partly explains the high drop-out rates or career change among newcomers to teaching. It is not unusual for teachers to make up for the missing link, using classroom experience as the primary source of learning. This choice between fearing to lose security through reliance on others' methods and freedom to carve out one's own ways is a major feature of the existentialist philosophy of Jean Paul Sartre, "who sees it as obligatory for every human being to choose for himself and to make his own decisions" (Downey & Kelly, 1987, p. 139).

Teachers construct their own world of learning, a meta-world through a process of what Kolb (1984) calls experiential learning⁶, especially when they realize the absence of any foreseeable prospects for professional development. School is the place where teachers' knowledge and teaching skills are continually tested, challenged, evaluated (for efficiency) and socially compared. Teachers feel left to their own devices on how well to cope with the changing needs of different classrooms within the same school setting. After an initial induction to school activities, teachers realize the need to construct a meta-world independently of the knowledge gained from ITE, partly through improvisation grounded in prior knowledge, partly resorting to commonsense approach (Westwood, 1997; Jackson, 1989), and often using first-hand information on assessing classroom needs.

⁵ Self-efficacy is belief or expectation about one's own ability to perform a given task successfully (ERIC's Thesaurus)

⁶ Experiential learning is a broad-based learning concept that encompasses learning in a variety of contexts and settings, where experience is the source of learning and development.

This epistemic dimension of learning foregrounds the idea that knowledge construction in teacher education may be viewed as a subjective endeavor: the novice teacher constructs a meta-world by abstracting and adapting from the world of the educator. Piaget (*op. cit.*) describes this epistemology as a form of dependency novice teachers initially build on educators. The dependency may be short-lived or entirely transient depending on the relevance and usefulness of the methodology courses of preparation programs. This study has yet to provide evidence of the extent of the educator's world as seen in the making of the new meaningful meta-world constructed by the teacher. Programs which are inherently deficient tends to breed a sense of alienation of teachers from the educator's world; the latter would often moot the existence of training institutions in favor of the pressing preoccupation of teachers constructing a world from the here-and-now observations stemming from workplace learning.

2.7.3 Teacher's self-efficacy

Ferraro (2000) relates the concept of coaching to improving teacher's self-efficacy, that is "teacher's belief that they can affect students' lives as well as the school motivate them intrinsically to grow." Wheatley (2002, p.5) considers teacher's efficacy (TE) - "teacher's belief in their ability to affect student outcomes" - to be a crucial factor for improving teacher education and promoting educational reform. Some scholars even equate the success of educational reforms to improvement of teacher efficacy. According to others (DeMesquita & Drake, 1994; Sarason, 1990) reforms that do not address teacher efficacy are doomed.

Bandura (1994, p.1) defines the notion of self-efficacy as "people's belief about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives." Teachers with high sense of instructional efficacy, besides creating learning environments conducive to development of cognitive skills in the classrooms, can motivate their students and enhance their cognitive development. Those having a low sense of efficacy about their teaching capabilities "favor a custodial orientation that relies heavily on negative sanctions to get students to study" (Bandura, 1994, p.1).

Teacher's efficacy changes substantially as they move increasingly into their profession. In the preparatory phases, the sense of self-efficacy increases to strong levels as they develop capabilities to master the academic and pedagogical materials of the preparatory programs. But as they discover that the methods of preparation program do not work, or is inadequate, for

nature of elementary mathematics instruction predicates the construction of individual worlds in the teaching profession.

Several other theories of adult learning highlight the relationship between learners and experiential learning. While Bruner's (1966) learning theory is predicated on the learner constructing new ideas and concepts on their current or past knowledge, Reigeluth's elaborationist theory suggests that, within a relevant context, concepts should be built from simple to complex with continuous reminding of the simpler ideas on which the more complex are based. This theory brings into perspective the hierarchical structure of mathematical concepts (Ernest, 1996) embedded within the realistic mathematics education (RME) paradigm and whose layers (namely concrete, semi-concrete, abstract) are functionally related to the Piagetian operational (pre-, concrete, and formal) processes in child developmental epistemology.

Having reviewed teacher development and learner needs as part of teacher preparation programs, the next section focuses on the school curriculum as an important component in teachers' development and school reform.

Section C: The primary mathematics curriculum

2.8 What is curriculum?

The word 'curriculum' has varied meanings. According to Wikipedia, a curriculum in education refers to the set of courses and their contents offered by an institution such as a school or university. Madaus and Kellaghan (1992) refers to curriculum as a specific course or program, which may be implemented in one class or across the nation, or it may refer to all of a student's experiences in school. In some cases, a curriculum may be partially or entirely determined by an external body (such as the National Curriculum in British schools). Farrant (1980, p. 24) considers curriculum as the "distilled thinking of society on what it wants to achieve through education." In this perspective, curriculum reflects the aims, values and priorities a knowledge society considers as important and useful

Borrowing from the National Council of Teachers in Mathematics (NCTM, 1989), Romberg (1986, p. 749) defines curriculum, in the context of school mathematics, "an as 'operational plan' for instruction that details what mathematics students need to know, how students are to achieve

the identified curricular goals, what teachers are to do to help students develop their mathematical knowledge, and the context in which learning and teaching occur.” The ‘operational plan’ also emphasizes components within a curriculum that include content, process, product as well as the context in which the curriculum is implemented. Madaus and Kellaghan (1992) argue that a definition of curriculum must also be made in terms of its aims and objectives as these precedes all other components and are antecedent to two associative terms that presently dominate the field, namely, assessment and evaluation. Other generic terms also associated with curriculum are: standards, accountability, teacher appraisal, but these are problematic as they assume different roles and levels of importance within different models.

Of the terms mentioned above, ‘assessment and evaluation’ come to the fore after the term curriculum. Madaus and Kellaghan (1992, p. 120) defines assessment as “an activity designed to show what a person knows or can do.” Assessment is largely based in the classroom with the teacher observing students as they go about their normal learning activities. On the basis of such assessment teachers can make important curriculum decisions, such as modifying teaching methods, reorganizing the class, emphasizing or re-presenting topics, or change the pace of instruction.

The term ‘evaluation’ has been given many definitions in the literature. However, the one proposed by Tyler in 1949 (Madaus & Kellaghan, 1992, p. 120) tends to exert considerable influence: “The process of evaluation is essentially the process of determining to what extent the educational objectives are actually being realized by the program of curriculum and instruction.” The definition emphasizes the appraisal aspect of a program or project rather than of an individual. However, the emphazes on achievement of educational objectives rather than on attainment of learning outcomes (what individuals learn in school) are at least as important an indicator of program quality, but the scope of the definition is limiting in terms of monitoring and strengthening evaluation practices. Madaus and Kellaghan (1992, p. 120) argue that outcomes are not an essential aspect of program evaluation “since information about outcomes does not necessarily tell us anything about other important aspects of a curriculum, such as the quality of its objectives or the way it has been taught.”

The limitations of the Tylerian, or ‘objectives’ approach, led to the development during the 1970s of a host of different approaches to evaluation, the most notable being those of the U.S. Joint Committee on Standards for Educational Evaluation (1981), the National Assessment of Educational Progress (NAEP), and the U.K. Department of Education and Science’s Assessment

of Performance Unit. In recognition of the need to monitor and strengthen evaluation, the U.S Joint Committee developed a set of evaluation standards and provided a broad definition of evaluation as “the systematic investigation of the worth or merit of some object, program, project, or materials” (Madaus & Kellaghan, 1992, p. 120). In contrast to the Tylerian approach of determining whether program objectives are being realized, the definition provides an inquiry connotation that underpins the process of evaluation. The NAEP evaluation approach is designed to assess the effects of curricula in schools throughout America; to identify weaknesses and strengths in student achievement; on the basis of this information, to improve the achievement levels of students. The Assessment of Performance Unit (U.K. Department of Education and Science) proposed an approach designed to monitor standards of achievement in a broader range of subjects.

2.8.1 The problematics of curriculum evaluation

As was described above, the problematic nature of curriculum and its evaluation imposes different types of activities when evaluating curriculum. At the classroom level, the teacher is in daily contact with students and since the nature of teaching necessitates continuous assessment, teachers’ role must be regarded as central in the evaluation activities of the school. According to Madaus and Kellaghan (1992), teachers’ evaluation of the curriculum may adopt informal activities to assess cognitive ability and scholastic performance through paper-and-pencil tests that they construct themselves. For the most part, it is subjective, informal, immediate, and ongoing, involving continuous monitoring of student behavior, scholastic performance, and responsiveness to instruction. Teachers’ key assessment tool is ‘performance assessment,’ that is, the observation and rating of students’ behaviors and products in contexts in which students actually demonstrate proficiency (Stiggins & Bridgeford, 1985, cited in Madaus & Kellaghan, 1992). Additionally, the nature of assessment varies with curriculum area; for example, in assessing performance in mathematics and science, teachers tend to apply an objective type tests (Madaus & Kellaghan, 1992).

2.8.2 Standardized testing: ‘teaching to the test’

Standardized testing is endemic in elementary education; criticism of a psychometric nature are levelled against it. For example, scores on tests of achievement in mathematics problem-solving are often correlated with scores on tests of language ability. This suggests that a mathematics test is actually measuring the linguistic ability required to understand the presentation of the problems

rather than the mathematical ability required to solve them. Educational tests also tend to become outdated as curriculum changes (Wikipedia). A common criticism of standardized testing programs in schools is that they encourage teachers to 'teach to the test.' That is, teachers concentrate on the parts of the curriculum they know will be covered on the test and neglect those that will not. This criticism is certainly worth considering as any form of testing will promote teaching to the test if the consequences of testing are serious even if teachers have foreknowledge of the test and the test is not comprehensive. One of the main advantages of standardized testing is that it is able to provide assessments that are valid and reliable, as well as results which are generalizable and replicable.

In contrast with other types of informal evaluation carried out by teachers, formal evaluation activities may adopt more formal approaches to evaluate the curriculum from outside schools rather than from within them. In its formality, the formal evaluation focuses on a variety of aspects or domains of curriculum, covering a range of components (Oakes & Carey 1989, cited in Madaus & Kellaghan, 1992).

2.9 The Context-Input-Process-Product (CIPP) model

The CIPP model (Stufflebean, 2003, cited in Madaus & Kellaghan, 1992) involves several core aspects: (i) context evaluation, which involves needs assessment; (ii) input evaluation, a process to identify and assess competing strategies; (iii) process and product evaluation, i.e. to monitor, document, and assess program activities; (iv) impact evaluation involves assessing a program's reach to the target audience; (v) effectiveness evaluation involves assessing the quality and significance of outcomes; (vi) transportability evaluation i.e. to assess the extent to which a program has (or could be) successfully adapted and applied elsewhere); (vii) sustainability evaluation involves assessing the extent to which a program's contributions are successfully institutionalized and continued over time; and (viii) meta-evaluation, i.e. a process to assess the evaluation's adherence to pertinent standards of sound evaluation.

Similarly, Stake (1990, quoted in Madaus & Kellaghan, 1992) distinguishes three elements in the educational process as the focus of evaluation: (i) antecedents (conditions existing prior to teaching and learning); (ii) transactions (e.g. pupil-teacher interactions); and (iii) outcomes (interpreted in a broad sense to include immediate and long-range, cognitive and conative, and personality and community-wide outcomes).

2.9.1 Tylerian model of curriculum evaluation

The Tylerian model of curriculum evaluation is based on an approach that matches objectives with outcomes in a process involving six major components of the curriculum (Madaus & Kellaghan, 1992):

(i) *Context*. Context has a central place in curriculum implementation. In considering context, reference is made to the characteristics of participating students, their current level of knowledge and skills (e.g., in reading, writing, and mathematics) and their needs and interests. Context is also premised on the importance of student needs as a source for formulating educational objectives. “Information on context is necessary to evaluate the appropriateness of recommended or utilized curricular materials and procedures as well as the extent to which student outcomes can be judged as satisfactory” (Madaus & Kellaghan, 1992, p. 128).

(ii) *General aims* (of the total school curriculum). People generally differ in what they perceive to be the aims and purposes of education. From the behavioral perspective, the general aim of education is of producing desired changes in individuals. However, there is no agreement on which characteristics should be changed or how they should be changed. Other acceptable goals of education such as ‘good citizenship’, ‘self-development’, or ‘self-realization’ must have recourse to value positions, though most aims are probably considered as ‘ideals,’ “which do not actually exist and toward which schools are expected to direct their activities without ever actually achieving them” (Madaus & Kellaghan, 1992, p. 129). A relatively recent view is that the aims of education have been informed by liberalism, with an emphasis on autonomy. The aim has been to mentally equip students to be autonomous individuals, able to live self-directed lives.

(iv) *Curriculum materials*. In the model, curriculum materials take various forms, e.g., a syllabus document, a curriculum guide, lesson plans, textbooks, supplementary reading materials, workbooks, teachers’ guides, software, laboratory equipment, audiovisual aids and other materials. By far, the formal description of curriculum as set out in a syllabus is an important curriculum document. Complete syllabi must state the content to be covered in sufficient detail to provide adequate guide for implementation and describe the precise skills the student should acquire or the level at which the content should be covered. The evaluation of curriculum materials for which the objectives are not explicitly stated require close examination of the materials to determine the objectives they imply. However, Madaus and Kellaghan (1992) argue that “like a toaster or car, a textbook can also be evaluated according to preset criteria:

readability, coverage of material, sexism, even durability of binding. Characteristics of the students for whom the curriculum is intended (e.g., grade level and level of achievement) are also relevant in the evaluation of materials” (p.130).

(v) *Transactions and processes.* Transactions are concerned with teaching of content, subject matter, skills, and values that students are expected to experience, acquire, or learn, as well as other subject matter, skills, and values that may not be intended in the curriculum but to which students are exposed in a variety of activities in the classroom and outside it (Madaus & Kellaghan, 1992). Transactions may also involve statements about skills and content which have to be translated into procedures designed to achieve the objectives. Oakes and Carey (1989, cited in Madaus & Kellaghan, 1992) argue for the need of ‘curriculum indicators’ to provide information on what students had the opportunity to learn, to examine curricular goals, textbooks, materials and other curricular domains concerning the breadth of content coverage, the depth of coverage, and the mode and sequence of content presentation.

However, curriculum indicators provide no information on classroom interaction. Interaction as an observational attribute of the teaching and learning process cannot be measured; it cannot even be known to have taken place through evaluation of program activities or combining it with outcomes. For this reason, most evaluation approaches focus on description of program activities than on program intents, because they attempt to respond to audience requirements for information and they take into account the different values of the people involved in a program. Madaus and Kellaghan (1992) argue that “one of the major criticisms of evaluations that focus only on output is that the antecedents of achievements are hidden in the so-called ‘black box,’ with the result that we do not even know if there has been adequate implementation of the planned curriculum; much less do we know what factors in its delivery might have contributed to or hindered the achievement of the proposed objectives” (p.131). However, evaluation that aims to provide descriptions of program activities simply imply a discontentment with the ability of quantitative empirical approaches to ascertain whether or not the goals of a curriculum have been achieved. These approaches have a profound influence on the character of teaching, the content of curricula, and the goals that schools seek to attain (Einser, 1983, cited in Madaus & Kellaghan, 1992).

(vi) *Outcomes.* Outcomes of education can be expressed as the end-of-program of objectives. Outcomes are among the most important considerations among policymakers, administrators, educators, and the society. The outcomes of education often reflects how program activities have

been conducted and how these are translated into achieving the goals of curriculum. If considerations of educational outcomes are premised on a student's general educational growth or on her mastery of specific curriculum materials, a test that measures general and particular higher-order educational knowledge and skills, and assess a student's ability to apply knowledge acquired in schools, might be more valuable than one closely geared to instructional experiences. Cronbach (1889, quoted in Madaus & Kellaghan, 1992, p. 132) argues that "whereas a test based on curriculum objectives may tell you how well the curriculum is achieving its objectives, if you want to know how well the curriculum is serving the national interest, you have to measure all the outcomes that might be worth striving for."

2.9.2 Scriven's goal-free evaluation model

A shift from the Tylerian view of objectives evaluation is attributed to Eisner's 'instructional' and 'expressive' objectives and to Scriven's 'goal-free evaluation' (Madaus & Kellaghan, 1992). These approaches to evaluation do not require a statement of objectives nor do they specify outcomes of instruction in the Tylerian way. Rather they are used to describe 'an educational encounter' – that is a problem or task to be tackled – not what students are expected to learn because of the encounter. In 'goal-free evaluation,' an evaluator is not told the purpose of a program: rather, the evaluation involves finding out what the program is actually doing, without knowing what it is trying to do. Presumably, if a program is successful in achieving its stated goals and objectives, this will become obvious to the evaluator during the course of the evaluation (Madaus & Kellaghan, 1992). While 'goal-free objectives' can conveniently be applied to evaluation of online/interactive learning systems (e.g., Open Learning System, WebCT) where the 'encounter' involves transactions and processes, the 'expressive objectives' approach to evaluation is realised after the 'encounter', e.g. "to visit the zoo and discuss what was of interest there" (Madaus & Kellaghan, 1992, p. 130).

2.9.3 Creativity in the primary mathematics curriculum

Creativity is a great catchword often associated with child development, typically with children in the early years of primary schooling. All too often children have a strong desire to convey their feelings and ideas about personally significant events and often to keep a record of them. Children experience impulses toward pictorial or plastic creativity and vent those impulses in literary and other forms of creative self-expressions. Teachers tend to believe that their teaching and other classroom activities are geared toward enabling children to think creatively. However,

there are few indications that teachers really understand the meaning and value surrounding this important construct in education, although teachers clearly wish to promote it. The aim of education has been thought of as 'growth' or development of individual potentialities (i.e. the all-round development of the child), while the curriculum, it has been argued, should arise from the needs and interests of children, not from the demands of the teacher (Hirst & Peters, 1975). But are our methods meant to make children think creatively? Is the curriculum differentiated to cater for individual needs to foster creativity? Do the education courses of teacher training programs teach skills in the development of creativity? Does the culture of the school have an ethos for promoting creativity in the classrooms? The answers to these questions, based in the Mauritian context, are clearly in the negative! An attempt at providing a plausible explanation is that, as most teachers, it is normal practice that we tend to teach what we know best and with what we are comfortable – not what children really need to know, and how they should know to develop their potential to the full for their all-round development.

As a unique species, the human being is endowed with the faculty of being creative to the extent that it has the potential to change its environment by the very essence of its nature. Everybody are creative. Everybody can learn to be more creative. Creativity is a natural quality that, if not allowed to bloom and flourish, withers away and dies in the absence of adequate opportunities for its nurture and development. Nor is creativity a dormant seed that flowers naturally. Our schools have very recently (in 2002) abandoned the ranking system that favored competition at all levels to the detriment of stifling the creative spirit of young children. The progressive and authoritarian approaches to education of the modernist era do not treat some children as moral beings with a right to enjoy their own very different world, "but as little manikins who must, from the very first, be forced into an adult strait jacket" (Hirst & Peters, 1975, p. 30). Creativity is vitally important and should feature across all school activities.

Creativity is receiving the profound attention of stakeholders as well as decision-makers in the provision of education for the preparation of the new generation of learners to face the challenges of the information age. The concern especially about the creative condition of the experience of children is being raised in educational circles worldwide. UNESCO (2003) for one is promoting the development of proper environment for creativity through arts education as a basic curriculum provision in all schools. It is committed to the belief that creativity remains the concern of every one as the access to new technologies opens the way to original forms of expression. Promoting creativity remains one of the best ways of maintaining cultural vitality (UNESCO, 2003).

Chapter 3

Research paradigms and methodologies

3.1 Introduction

This chapter explores research paradigms in search for a methodology¹ or a combination of methodologies to investigate the educational issues addressed in this study. These issues have social, educational and human dimensions to be evidenced through the proper choice of research paradigms and methodologies to guide our understanding of the investigation. Much of the debate on the discourse of methodological stances in the social and human sciences have polarized the objective, quantitative approach with emphasis on quantification and objectivity on the one hand, and the subjective, qualitative approach, with emphasis on the descriptive and the interpretative, on the other. To a very large degree it is the nature of the investigation to be addressed that guides the choice of methodologies for a particular study. This part of the study develops an epistemological framework for the selection of a research paradigm which eventually leads to the choice of appropriate methodologies “within a postmodern research method” (Pillow, 2000, p. 1). The postmodern approach is viewed as a conflation of methods and methodologies with an epistemological underpinning of the context of the investigation.

The study is grounded in an investigatory framework with an empirical and a developmental focus in that its findings are expected to provide technically valid guidelines in answering the research questions in section 1.11 (Chapter 1). Grounding this research in a postmodernist framework provided the structure for the construction of the research questions and the methodologies of inquiry in this study. The design of research and its role in educational practice represents a new urgency to the researcher, both as a teacher educator and researcher. This urgency is further coupled with the focus on the immediacy of the relevance of the results to educational policymakers as well as practitioners and the education community at large.

¹ A *methodology* is a theory and analysis of how research does or should proceed; a research *method* is a technique for (or way of proceeding in) gathering evidence (Pillow, 2000).

3. 2 The research practice gap

From a postmodernist perspective, much of the research in the social and behavioral sciences may appear to be esoteric and not responding adequately to the needs of decisions makers in education. According to Shavelson and Berliner (1991), in the public perception much of what is published in educational research is regarded with skepticism and often associated with educational faddism or “pointy-headed intellectualism” (p. 79). The authors further argue that educational research has not produced enough useful findings, or that the findings have not fulfilled its role in an effort to improve our schools, nor provide instructors with reliable and effective methods of instruction for our children to the extent that the dilemmas facing our educational system are fixed. Many proposals have been more of an embarrassment to the education community in terms of “dubious experiments, worn-out hypotheses, disorganized writing, missing information and ungeneralizable results” (Shavelson & Berliner, 1991, p. 79). Consumers of research, more specifically policy makers in education with instances of decision making processes, regard with skepticism research findings that lack sound, verifiable ‘scientific basis.’ To illustrate a single instance of this point, in the U.S.A., federally funded programs and practices are required by legislation² to be grounded in ‘scientifically based’ research. More recently, the U.S. Department of Education³, in “... seeking to ‘transform the field’ by supporting only studies that are backed by ‘qualified scientists,’ that ‘address causal questions,’ and that ‘employ randomized experimental designs’”, has privileged quantitative, experimental research (Flinders, 2000, p. 380). If research is to inform decision making and guide practice, then the goal of research is beyond “ways of seeing” or gaining understanding through a process of discovery. The stakes on research outcomes informing decision making processes and practice are high without a theoretical, scientific foundation.

Levin (1991, p.78) postulates that “... educational research is expected to solve educational dilemmas because such problems are considered to be technical in nature.” However, the nature of the problems associated with the issues raised in this study and the foreshadowed problems of low performance, high drop-outs, and rampant private tuition and that are linked to teachers’ work are essentially social and technical in nature. These interacting variables encapsulate a convex combination of objects and methods that will define the research terrain. While the

² No Child Left Behind (NCLB) Act of 2001

³ U.S. Department of Education, Strategic Plan 2002-2007. The strategic plan precludes qualitative research altogether. Available: www.ed.gov/pubs/stratplan2002-07/index.html/ Accessed 18 February 2004.

objects represent the problems inherited from a modernist context and are social and technical in nature, the methods are essentially postmodernist. Thus, a brief delineation of the epistemologies and ontologies of different paradigms would serve to locate the combination of methods employed in this study.

3.3 The concept of a research paradigm

The Wikipedia encyclopedia refers to the word *paradigm* as a thought pattern in any scientific discipline or other epistemological context. The word has also been associated with setting a worldview that underlies the theories and methodologies of a particular scientific investigation. Kuhn (1962) defines a paradigm as being a set of interrelated assumptions about the social world which provides a philosophical and conceptual framework for the organized study of that world. In this sense, Kuhn's (1962) paradigm theory uses the concept of paradigm in two fundamental senses – one sociological, and the other psychological. In the sociological sense, the typical concept of a paradigm is implied and Kuhn (1977) formulates it 'in a sense close to that for which (he) ...suggested a 'disciplinary matrix'⁴' (p. 307).

The Kuhnian 'disciplinary matrix' represents a set of paradigmatic activities analogous to the structure of the mathematical entity known as an 'elementary matrix.' In an alternative presentation applied to the study of Markov chains (in market research), the entries of a matrix constitute elements representing a dynamically time-dependent process that reaches an equilibrium or stable state commonly known as the 'steady state.' The Kuhnian 'paradigm shift' endorses a 'steady-state' model of the matrix reifying a fixed rather than a change process. The author argues that the paradigmatic activities are divorced from the notion of a 'paradigm shift'; a sequential presentation of the set of beliefs and assumptions would serve to better guide inquiry. With this formulation the focus shifts onto research as the way its praxis is conducted in the sciences.

⁴ Kuhn outlined four components of the disciplinary matrix: (a) symbolic generalizations (agreed-upon laws or formal expressions of theoretical relationships); (b) commitments to particular models (models were to provide permissible analogies and metaphors that help determine acceptable explanations); (c) values about the way to practice science and judge theories; and (d) exemplars, the accepted solutions to the problems that prospective scientists are exposed to in laboratories and textbooks. In brief, the disciplinary matrix encompasses our commonly shared generalizations, our assumptions and beliefs, values, and examples of what constitute the discipline's interests.

In the latter sense, the concept of paradigm shifts radically from the monolithic notion of a scientific method, initially rooted in the natural sciences, to be regarded as 'a learning theory.' Guba and Lincoln (1991) argue that "it is useful to think of a paradigm as a basic set of beliefs, a set of assumptions..., which serve as touchstones in guiding our activities" (p. 158). This perspective makes explicit the notion of a 'paradigm shift' in the sense that a paradigm not only shifts but also changes along the research terrain with the 'disciplinary matrix' as its basis.

Following the above discussion on the nature of a paradigm, the question that comes to the fore is: what are the basic beliefs and assumptions undergirding the notion of a paradigm? Our basic beliefs are dictated by the philosophical stances within which the paradigm is located and the historical context of the investigation, while our assumptions are guided by the epistemologies and ontologies that guide the choice and selection of the consequent methodology. Thus, paradigm bears with it a set of beliefs and assumptions that define the many different ways of exploring a question that is considered legitimate for understanding and for producing knowledge and meaning. It is regarded as the very basis on which one builds knowledge and understanding about social reality, how society works, how humans behave, their actions, and about how to change them for the better. Settling on a research paradigm would also shape how we understand ourselves, our interventions and strictures, our assumptions, biases and choices, and how we produce knowledge for meaning and understanding. Ruskin (2004b) argues that "the assumptions that guide our interventions are the essential components of a paradigm; they may be so much a part of how one views the world that the assumptions are taken for granted as 'how things are.' In other words, one may choose a paradigm without even realizing it and without knowing there are alternatives" (p. 2).

3.3.1 The choice of a paradigm and method

On the question of choice of a research paradigm and method, Reeves and Hedberg (2003, p. 272) caution that "research methods should not be selected until a researcher is clear about her/her research goals as well as the nature of the particular questions to be addressed within a particular study." As discussed above, this study has a dual focus in its objectives: it is both ethnographical and developmental. Hence a brief delineation of these two conditions serves to locate the particular paradigm or combination of paradigms advocated in this study.

Reeves and Hedberg (2003, p. 29) further argue that “the prospect of a new paradigm for inquiry emerging from time to time in a field is very powerful.” Based on this premise and the nature of the investigation, the researcher attempts to delineate the epistemological, ontological, and methodological assumptions of the following three paradigms drawn eclectically from postpositivist and postmodernist influences to investigate the empirical aspect of this study. In the researcher’s view, the notion of postpositivism and postmodernism characterizes particular historical moments in the manner of Foucault’s famous *epistème*⁵ according to which it is claimed that “each age organizes its knowledge differently from preceding and succeeding ages, but that within the circumference of a particular *epistème* different branches of knowledge will organize their data according to the same principles” (Sturrock, 2003, p. 72). In brief, paradigms provide the degrees of freedom that guide researchers in methodological pathways within the process of an inquiry.

3.4 The eclectic-mixed methods-pragmatic paradigm

The overall method of investigation in this study is based on an eclectic-mixed methods-pragmatic approach. Regarded as ‘a good fit’ in this study, the approach draws from several research paradigms, namely (i) postpositivist-critical focus group ethnographic-qualitative paradigm, (ii) the postmodernist-interpretative hermeneutics-qualitative paradigm, and (iii) the deconstructionist-positivist-radical constructivist-mixed method paradigm. As each paradigm will guide the investigation, and each will be discussed in the ensuing sections. The paradigms have a developmental research focus of the analytical kind and provide a concrete, theoretically-based direction for organizing the investigation.

The context in which the term ‘eclectic’ is used is *not* about ‘choosing the best’; it is used in a neutral sense about theories that use parts from different theories (Wikipedia). In this sense, the paradigm borrows ‘the beliefs’ and ‘assumptions’ of other paradigms in ‘guiding activities’ (Guba & Lincoln, 1992). Based on this proposition, the method of the ‘eclectic-mixed methods-pragmatic paradigm’ is to select from the above three paradigms aspects normative to developmental research inquiry, and, in the process, incorporating a mix of qualitative and

⁵ *Epistème* is the Greek word for knowledge. Foucault uses the word in two senses – as an epistemology, and a paradigm as an inclusion within the *epistème* framework.

quantitative methods. The paradigms have a mix of postpositivist and postmodernist orientation to provide the multiple perspectives for the investigation.

The ‘mixed methods’ aspect of the paradigms relate to the recognition that multiple perspectives are needed to ‘triangulate’ information and conclusions evidenced from complex phenomena (Reeves & Hedberg, 2003). The ‘pragmatic’ aspect presupposes an optimistic belief that, “although ultimate prediction and control may never be achieved in the design and implementation of interactive learning systems for education and training, things can get better” (Reeves & Hedberg, 2003, p. 35).

3.4.1 Postpositivist-critical focus group ethnographic-qualitative paradigm

According to Ruskin (2004b), *postpositivism*, also known as heuristic paradigm, was imported by Martha Heineman Pieper into the field of social work as early as 1981. Since that time authors in other fields have also adopted the paradigm, including Guba and Lincoln in education. Postpositivism provides a framework to investigate the legitimate problems and theories in the study of a particular discipline. In the field of empirical research, it is practiced in two forms – social constructionism and fallibilistic realism. Postpositivism is a recent evolution of positivism and logical positivism⁶.

According to Gephart (1999), postpositivism assumes an objective world, but unlike positivism with its strong focus on experimental and quantitative methods in its search for causal relations of an objective world, postpositivism “assumes the world might not be readily apprehended and that variable relations or facts might be only probabilistic, not deterministic” (p. 4). Thus postpositivists are using naturalistic and phenomenological approaches (Miles & Huberman, 1994) in the appropriation of knowledge from reality. The epistemic character of real world

⁶ Logical positivism dominated social and behavioral sciences for decades (until early 1980s) and never had its fundamental tenets formulated in a way that was clearly consistent and so were considered completely unfounded and logically inconsistent. One of its tenets, namely the ‘verifiability criterion of meaning’ did not seem verifiable and presented severe problems for the logical consistency of the theory (Wikipedia). It is argued that its restrictiveness has had unfortunate consequences for the human sciences. Among the most significant are unsolved problems of the modernist era still plaguing the field of education: the gap between theory and practice knowledge, between researchers/educators and practitioners, and rejection of the notion of an alternative curriculum for learners in the information age. In sum, logical positivism has caused very detrimental effects by devaluing as ‘unscientific’ much of practitioner-generated research and as such has never been used in other sciences.

phenomena is such that, logically there is a focus on falsification rather than verification so that “only one counter example or feature is needed to falsify a proposed relationship” (Miles & Huberman, 1994, p. 4). This is implicit to the objective proposition of fallibilistic realism that empirical knowledge can be agreed upon though they cannot be proved with certainty. Bradbury (1999, p. 75) argues that “with this goal in mind, the empirical data supporting any claim must be extensive, including as many cases as possible, resolving any and all anomalies.” It follows that a basic tenet of postpositivism resides in that one must assess all possible variables to verify a relationship is consistent across all conditions. “Further, increasing effort is devoted to establishing the domain of generalizability of findings based on the features of the sample and sampling context” (Gephart, 1999, p. 4).

Critical focus group ethnography is a conflation of two rather differing worldviews – critical theory and focus group ethnography scholarship. According to Kincheloe and McLaren (1994), critical scholarship seeks to uncover forms of inequality and injustice which characterize contemporary society’s educational system. The approach seeks to transform society into more equitable, democratic institutions through transcending taken-for-granted beliefs, values and social structures. By encouraging self-conscious criticism and by developing emancipatory consciousness in social members in general, it seeks to make these structures and the problems they produce visible for creating awareness. The goal of critical theory is social transformation through displacement of existing structures antithetical to emancipation and empowerment, the development of more equitable, democratic structures and the opening of opportunities for social participation among persons previous excluded and dominated (Gephart, 1999).

Focus group ethnography is from two perspectives – ethnography and the focus group tradition of qualitative research. According to the Cohen *et al.* (2000) *ethnography* refers to the qualitative description of human social phenomena, based on months or years of fieldwork. Ethnography may be ‘holistic,’ describing a society as a whole, or it may focus on specific problems or situations within a larger social scene. It is regarded as a valid research method that submerges the subjectivity of a researcher in the routines of an alternative social environment to discover its specific and otherwise unpredictable patterns (Wikipedia). Ethnographic methods tend toward the descriptive. The genre has become the staple in social sciences to reach communities of practice in an attempt to build multiple lens in the study of their customs and behaviors. According to Patton (1990), the primary method of ethnographers is participant observation, a technique central to the anthropological method of participant observation. It entails intensive fieldwork in which

the investigator is immersed in the culture under study. Gertz (quoted in Bradbury, 1999, p. 81) observes that, in participant observation, “rather than trying to objectively describe events, the researcher deliberately enters the world of those whom s/he is studying in an attempt to reconstruct the meanings that they attach to events and relationships.”

The *focus group* attribute of the ethnographic tradition is one of several research tools that is gaining popularity among researchers and evaluators to generate valid information, important to the advancement of programs and communities of practice as in this study. The method provides trustworthy, reliable naturalistic data that also leads to important insights in human behavior, yet the data are not set up to generalize in the same way as survey research. The method entails group interviews that tie up within an ethnographic framework and functions more as an appropriate data collection strategy than participant observation, characteristics of ethnographic research. Patton (1990, p. 335), in referring to the profile of participants in ethnographic studies, refers to them as “a relatively homogeneous group of people who are asked to reflect on the questions asked by the interviewer.” The participants in the group share a common interest. Although there is no need to reach consensus or disagreement, participants are given to hear each other’s responses and to make additional comments beyond their own responses. This condition may constrain the discourse and therefore bias the data through interviewee interaction or when one person tends to monopolize the conversation while others, who might not be so verbal, tend to share the same views. A sensible way to resolve this problematic is to resort to triangulation. Triangulation seeks to consolidate the veracity of factual evidence, data or information gathered through multiple perspectives or mixed methods. Reeves and Hedberg (2003, p. 35) build on this perspective by claiming that “multiple perspectives are necessary to ‘triangulate’ ... information and conclusions regarding complex phenomena.”

Focus group ethnography portrays a combined approach of eliciting information through in-depth focussed interviews rather than simply ‘just observing’ members of a group in natural settings with the inherent risk of the observer going ‘native’ in the culture under study (Cohen *et al.*, 2000). Focus group ethnography’s greatest strength lies in its provision for capacity building in researching sensitive issues through the development of dual lenses that combine in-depth individual and group interviewing with participant observation in natural settings. Yet, the inherently mediated nature of social reality and the complexity of changeable human phenomena have important epistemological implications for the kind of goals that are appropriate for explanation through empiricism and objectivity.

Basically, *qualitative* methods are research methods that make no attempt to measure or count, but rather tries to capture the complexity of social phenomena through interpretative inquiry that focus on the details and nuances of people's words and actions. This emphasis on human beings as the primary source of data is central to the empirical and developmental nature of this study. An interpretative inquiry paradigm embedded in the qualitative tradition and an empirical-inquiry within a quantitative tradition serves to provide a mixed method approach for this particular investigation. In this sense, qualitative and quantitative techniques are regarded neither as mutually exclusive methods nor conflicting or oppositional frameworks in contemporary research. The modern tendency is to an eclectic approach that favours qualitative methods to be used in conjunction with quantitative methods. One is used to complement the other. Often quantitative methods produce numbers whose meaning can be described by qualitative methods; qualitative ideas and expressions often find meaning in quantitative methods.

3.4.2 The postmodernist-interpretative hermeneutics-qualitative paradigm

Postmodernism has been variously described as a philosophical approach, a reaction to modernism (of the Enlightenment, the logic of reason period, and post-Fordism), a significant force (to interrogate the phenomena created by modernism – for example, conception of instructional technology of the Information Age) and a philosophical condition. It has, in its evolution, defied a singular definition. Postmodernism also acknowledges multiple perspectives (see 1.7.2), considers education as an object for 'de-commodification' and knowledge as a shared entity. In this study, the approach is further expanded to endorse 'postmodernism' as a questioning epistemology of an objective reality located in postmodern era, a period that coincides with application of educational technology with the advent of the information age. From this perspective, postmodernism provides the theoretical lenses to question the postmodern conditions generated by modernism. Thus, grounding this research theoretically in a postmodernist framework provides structure for the construction of the research questions (see 1.11) and development of a methodology for the inquiry.

Pollock (1981, p. 2) calls *hermeneutics* the "art of interpretation." Aside from it being about interpretation, meaning and understanding, Pollock (1981) argues that hermeneutics is also about constructing an opposition to the assertion of positivism that all true knowledge is scientific. Drawing from Heidegger's modern conception of hermeneutics, with influences from

existentialism, the act of interpretation is regarded as an innate characteristic of humans and is carried out in daily life. This aspect of hermeneutics complements two basic claims drawn from Husserl's theory of phenomenology: first, most objects go 'uninterpreted' because we take their existential nature for granted, and secondly that phenomena only become objects for interpretation when they "constitute a breakdown in understanding" (Pollock, 1981, p. 2).

Basically, two categories of hermeneutics have been identified in the literature – hermeneutics of everydayness and depth hermeneutics, or critical hermeneutics. Hermeneutics of everydayness seeks to illuminate and articulate phenomena that generally go unnoticed because it is ubiquitous, commonplace, and everyday. In this category, hermeneutics is used for content analysis (as in this study) to unravel anomalies in interpretation of texts, symbols, and language that often obfuscate understanding and lead to misconception. The latter category is often associated with the works of Freud, Marx, Nietzsche and seeks to uncover what has been hidden, covered over, and disguised, an approach that points to the process of deconstructing signs and symbols in the search for an alternative method to construct meaning, especially in semiotics. Hermeneutics is thus entrenched within an interpretative inquiry paradigm with tools for analyzing texts, symbols and artifacts in a process aimed towards developing alternative curricula. Reeves & Hedberg (2003, p. 32) acknowledge "more recently, hermeneutics has come to mean the analysis of curriculum in the broadest sense and instructional programs and products in a more focused sense. ..." A basic tenet of this process resides in reading and interpreting text based on one's knowledge of the language and symbols in which the text is written. A text is open to reading and re-reading with interpretation and semiotics being integral parts of the process. The techniques also engage the researcher into questioning the conditions under which the act took place (that is, the reading and interpretation process), and the conditions under which a product is produced that makes it possible to interpret its meaning (Patton, 1990). The inquiry process subsumes 'sense-making' and meaningful cognitive unfolding in the search for new (or alternative) ways of making meaning out of language and 'symbolic interaction.'

Pollock (2002) argues that one criticism of hermeneutics is its relativism, in relation to the object of analysis; for example how can one know what interpretation is best. Inwood (quoted in Pollock, 2002, p. 4) claims that "we cannot be sure that our interpretation is correct, or better than previous interpretations. Our interpretation, and our verdict of previous interpretations, is open to future revision. In interpreting a past text we explore our own pre-understanding as much of the

text itself.” Pollock (2002, p. 4) further argues that “it is likely that as we interpret iteratively through the hermeneutic circle we obtain a growing understanding.”

According to Guba and Lincon (1991) hermeneutics as a process of inquiry has a constructivist epistemology in that “it is aimed toward developing improved (joint) constructions, a meaning closely associated with the more traditional use of the term to denote the process of evolving successively more sophisticated interpretations of ... writings. It is dialectic in that it involves the juxtaposition of conflicting ideas, forcing reconsideration of previous positions” (p. 164).

3.4.3 The deconstructionist-positivist-radical constructivist-mixed method paradigm

According to the Wikipedia encyclopedia, deconstruction is highly resistant to a succinct, formal definition. It belongs to a school of criticism developed by the French philosopher Jacques Derrida. Deconstruction is not the antonym of ‘construction’ nor the synonym of ‘destruction’. According to Derrida, to explain deconstruction, it is easier to explain what deconstruction is *not*. Deconstruction is neither an analysis, a critique, a method, an act, or an operation. According to Barbara Johnson (quoted in Wikipedia),

[Deconstruction] is in fact much closer to the original meaning of the word 'analysis' itself, which etymologically means "to undo"—a virtual synonym for "to de-construct." ... If anything is destroyed in a deconstructive reading, it is not the text, but the claim to unequivocal domination of one mode of signifying over another. A deconstructive reading is a reading which analyses the specificity of a text's critical difference from itself."

Deconstruction has been applied to many disciplines in the natural and human sciences, including mathematics.

In this study, deconstruction⁷ serves as a tool of postmodernism in the analysis of the binaries of an idea or a concept. The approach takes a critical stance to view cause-effect relations, to critique the distortions and dissonance created by what critical theorists call the ‘hidden’ curriculum. Though the goal of deconstructing curriculum (mathematics) is to de-construct concepts and artifacts that constitute the learning materials for objective knowledge, setting up

⁷ Deconstruction was highly controversial both in academia, where it was accused of being nihilistic, parasitic, and just plain silly, and in the popular press, where it was often seized upon as a sign that academia had become completely out of touch with reality. Despite this controversy

equity in attainments remains the quintessential outcome of this inquiry. Although deconstruction has not been used to construct anything yet, the approach will serve to seek an answer to the question: Is it our beliefs and reliance on human artifacts that is the cause of the *status quo* and inequity in our educational system?

According to Cook (1991), Karl Popper defines *positivism* as the ‘empty bucket’ theory of induction, meaning (i) some associations repeatedly occur in nature that can be validly observed by the senses and that bring no prior knowledge to bear, and (ii) from these observations general laws can be induced. Theodor Adorno “assumes that totally explicit theories are possible from which hypotheses can be deduced that can subsequently be confronted with empirical data that will confirm or reject the theory from the hypotheses were derived” (Cook, 1991, p. 44). Unlike Popper’s logico-deductive conception of positivism, Adorno assumes a more hypothetico-deductive framework. These opposing views represent a false antinomy that tend to dichotomize the methods of social and natural sciences into two distinct paradigms of inquiry – the empirical and the scientific. These antinomies find a nexus explicit in the dialectical adaptations underpinning Einstein’s theory of relativity and the theoretical adaptations of Schrödinger’s wave equation in the study of quantum physics (mechanics). Cook (1991, p. 44) argues that “scientific practice has multiple origins that include the trial-and-error behavior of practitioners, selective adaptations from prior philosophies, and research on research.” Positivism is characterized by scientific beliefs and practices and a realistic ontology (that reality exists outside of the mind). Thus, positivists are realists and assume that the world is lawfully ordered and that the major task of science is to describe the order.

According to von Glasersfeld (1995), *radical constructivism* is a theory of knowing proposed as an alternative to the long-dominant epistemological theory of objectivism. The theory assumes that reality has an inherent, observer-independent, objective structure and it is possible to attain ‘true’ or objective knowledge by means of rational thought processes governed by the rules of propositional logic. The theory does not deny the existence of reality (‘out there’). Reeves and Hedberg (2003) argue that reality is a matter of individual cognition, each observer “interprets the external world according to his or her own experiences, beliefs and assumptions” (p.13), yet we do not have any method of attaining ‘true’ or objective knowledge.

This aspect of radical constructivism is applied in this study for purposes of ‘curriculum re-engineering’ in search for an answer to the question: What curriculum for the information age?

3.5 The developmental research focus of the study

According to Cohen *et al.* (2000, p. 169), developmental research involves a collection of longitudinal, cross-sectional and trend or prediction studies as these are concerned with the description of the “present relationships among variables in a given situation and to account for changes occurring in those relationships as a function of time.” The concept has been appropriated and applied to diverse educational, historical, sociological and psychological phenomena. Given the complexity and scope of this study, developmental research provides the tool to gather data at a particular point in time with the purpose of describing the nature of existing conditions or determining the relationships that exist specific events, for example between curriculum restructuring and teacher development, or between performance standards in schools and teacher preparation programs. In this study, developmental research is employed in connection with longitudinal studies to gather data over an extended period of time and to deal specifically with aspects of human growth, for example in ‘cohort study.’ According to Cohen *et al.* (2000), the term ‘cohort’ (in the British literature) refers to a group of people with some common characteristics. (The equivalent term in the United States is ‘panel study’.) Unlike a panel study, in cohort study a specific population is tracked over a specific period of time and the population is sampled for ‘a selective sample,’ which means that some members of a cohort may not be included each time. By contrast, in a panel study in individual is tracked over time. In this study, the term ‘cohort’ refers to pre-service or in-service teachers attending preparation or upgrade programs at the MIE, and ‘cohort study’ refers to the ongoing longitudinal methods of collecting information about individuals and monitoring of specific events.

In the longitudinal approach of cohort studies, the analysis will focus on aspects of teacher growth and development to identify typical patterns of development in terms of learning needs of teachers. The approach permits examination of individual variations in characteristics or traits and establishes causal relationships in an attempt to explain the changes that occurred as a result of changes in the career life-cycles of teachers. The approach is less expensive, it produces findings more quickly, and respondents are likely to be more cooperative. However, cohort studies have been found to pose considerable problems of organization due to the continuous changes that occur among respondents; for example, each cohort of pre-service and in-service teachers may have slight variations in their perceptions of their preparation and upgrading programs. Such changes make it highly unlikely that a study will be completed in the way that it was originally planned (Cohen *et al.*, 2000).

3.5 Curriculum analysis procedure of school mathematics textbooks

Borrowing from Project 2061 (Kulm & Grier, 2004), the analysis procedure for mathematics curriculum materials (based on K-12 school) is based on a study of the degree of alignment of the content of curriculum materials to selected learning goals. While seeking to match content to (Bloom's taxonomy of learning) objectives, the procedure pays particular attention to the various criteria used to evaluate the instructional effectiveness of the materials.

The procedure focuses on the following action points (a) identify specific learning goals to serve as the basis for analysis, (b) inspect the curriculum materials to identify those content that appears to correspond reasonably well to the learning goals. Materials that do not meet these initial criteria are not analyzed further. And (c) analyze the curriculum materials for alignment between content and selected learning goals. As a first step, reviewers agree upon a set of learning goals as a framework for the analysis. When evaluating stand-alone curriculum units that cover a relatively short period of time, it is recommended to analyze all the learning goals that appear to be targeted by the material. However, in the evaluation of year-long courses, a sample of a few learning goals invariably lead to valid and reliable generalizations about the material.

This analysis is a more rigorous examination of the link between the subject matter and the selected learning goals and involves giving precise attention to both ends of the match; the precise meaning of the learning goals on one end, and the precise intention of the material on the other. According to Kulm and Grier (1990, p. 9), "the material is examined using such questions as (i) Does the content called for in the material address the substance of a specific learning goal or only the learning goal's general 'topic'? (ii) Does the content reflect the level of sophistication of the specific learning goal, or are the activities more appropriate for targeting goals at an earlier or later grade level? (iii) Does the content address all parts of a specific learning goal or only some?" The procedure also requires the reviewer to estimate the degree of overlap between the material's content and the set of learning goals of interest. (iv) Analyze the curriculum materials for alignment between instruction and the selected learning goals. The purpose is estimate how well the material addresses targeted learning goals from the perspective of what is known about student learning and effective teaching.

3.6 Content analysis

According to Cohen *et al.* (2000, p. 164), content analysis is defined “as a multipurpose research method specifically for investigating a broad spectrum of problems in which the content of communication serves as a basis for inferences.” The method involves identifying appropriate categories and units of analysis, both reflecting the nature of the document being analyzed and the purpose of the research. In addition to elucidating the content of the document, the method may throw additional light on the source of the communication, its intended recipients, and those to whom the message is directed (Cohen, *et al.*, 2000).

Manning and Cullum-Swan (1994) suggest that content analysis is a quantitatively oriented technique by which standardized measurements are applied to metrically defined units and these are used to characterize and compare documents. The authors acknowledge that, apart from methodological issues of sampling, generalization, validity and reliability associated with quantitative techniques, “content analysis has been unable to capture the *context* within which a written text has meaning” (p. 464). Eco (quoted in Manning & Cullum-Swan, 1994, p. 464) defines context “in terms of an ongoing narrative..., the immediate semantic environment, the literary tropes operating, and connections between the text and experience or knowledge.” Levinson (quoted in Manning & Cullum-Swan, 1994, p. 464) “defines *context* as a matter of pragmatics, ‘what the reader brings to’ ... the text.” In this study, the context-content rapport of texts is investigated from an ethnomethodological perspective in an “attempt to understand context as the taken-for-granted knowledge brought to the experience and displayed in the talk” (Manning & Cullum-Swan, 1994, p. 464).

3.6.2 ‘Language of description’ and analysis of school texts

Dowling (1996) shows how a sociological ‘language of description’⁸ (Berstein, 1995) can be constructed to be used for the analysis of school mathematics texts. What is ‘a language of description’? Dowling (1996, p. 389) describes “a language of description ... as a conceptual structure which enables the reading of empirical information in terms of a coherent theoretical position.” In this case, the empirical information is given by a set of school mathematics texts. Dowling adopts an inductive approach to build the main features of the language through a practical analysis of extracts from the texts. In this study, a language of description, based on the work of Dowling (1996), and an analysis of the degree of consonance between learning

objectives and content of curriculum materials will constitute the framework for investigating the theoretical concerns and the mathematical texts.

3.7 Conclusions

This chapter has dealt with the issue of how paradigms and methodologies guide development of research methods. The paradigms are formulated within two theoretical perspectives - the postpositivist and the postmodernist. These provide the basis to investigate the complexity of the issues and problems discussed in Chapter 1 and serve as guide to re-conceptualize the theoretical and conceptual frameworks of the study. The next chapter considers the application of the paradigms and methodologies in collecting and analyzing the data and information with respect to the research questions formulated in section 1.11.

Chapter 4

Collection and analysis of the data

4.1 Introduction

In this chapter, the focus is on describing the instruments used in the collection of data and the methods used to analyze the research data. However, this stage of the study becomes problematic in determining the mode of data analysis to be employed - whether to develop a linear framework as starting point, follow a particular orientation, qualitative or quantitative, or a hypothetical genre of answering research questions. Much of the analysis is guided by the nature of the theoretical concerns formulated and issues raised in the study, the empirical data, and the instrumentations used. A mixed-method combining qualitative and quantitative approaches is used to guide the analysis.

4.2 The ethics of educational research: Fieldwork and informed consent

Ethics in educational research are to do with the regulatory codes that govern research practice. 'Good' ethical practice requires researchers "to strike a balance between the demands placed on them as professional researchers in pursuit of truth, and their subjects' rights and values potentially threatened by the research" (Cohen *et al.*, 2000, p. 49). Referred to as 'costs/benefits ratio', the concept is fundamental at the planning of the fieldwork where researchers have to consider the likely social benefits of their endeavors against the personal costs to the individuals taking part.

The fieldwork in this study takes place in two different locales, namely the teachers' place of work (i.e. the schools) and the teacher training college where teachers attend preparation programs and face-to-face instructional sessions as part of in-service upgrading programs. The term fieldwork is used to describe activities taking place in a particular research locale over the medium to long term (Bechhofer & Paterson, 2000). Fieldwork also involves the tasks of obtaining access to people and the locale where the research is conducted. The researcher's long-term involvement in teacher education and frequent visits to schools in the context of assessing trainee teachers on teaching practice placements rendered the fieldwork process entirely smooth

and safe. Most teachers sampled for this research showed an incredible willingness to be interviewed, to answer questionnaires, or to be 'facilitators' in this research project. Participants were briefed on the aims and purposes of the study, the way questionnaires were to be collected, and the various phases of the research study. Anonymity of participants was guaranteed so that information provided by participants would in no way reveal their identity.

A plausible explanation of this unusual willingness and positive attitude to collaborate with the researcher may be attributed to the desire of participants to join hands, though indirectly, in the on-going reform process through an interlocutor whom they take (mistakenly!) to be close to decision making and who, they feel, could impact their worklives. The rapport and entente developed between instructors and teachers at the time of pre-service and in-service programs usually extend into their worklives. On the other hand, instructor's attitude to teacher education is to ensure an enduring working relationship between schools and the unique training institution.

4.2.1 Gatekeepers and key informants

Cohen *et al.* (2000) argue that the researcher is in a difficult position to evaluate key informants, to decide whose accounts are more important than others; which informants are competent to pass comments; which are reliable; how knowledgeable informants actually are; how to meet and select informants; and the relationship between the informants and others in the group or situation being studied. However, LeCompte and Preissle (1993, quoted in Cohen *et al.*, 2000, p.145) caution that "the first informant ... might be self-selected people who are marginal to the group, have a low status, and who, therefore, might be seeking to enhance their own prestige by being involved in the research." Cohen *et al.* (2000) argue that "the researcher must be careful to use informants rather than informers, the latter possibly having 'an axe to grind.'" Researchers who are working with gatekeepers... will be engaged in a constant process of bargaining and negotiation" (p. 145). Based on this perspective, the researcher utilized gatekeepers in the persons of senior teachers and school administrators (deputy head teachers, head teachers, and government primary school inspectors) as key informants for interviewing. The interviews were conducted either on school premises or, occasionally, in the researcher's office, wherever it was convenient and cost effective.

The process of sampling and selecting key informants, especially for interviewing, involves issues of interpersonal relationships. These were addressed through building participants'

confidence in the researcher by developing rapport and trust, showing attention and being an active listener. These traits were combined with the critical decision on how long to stay. Good interpersonal relationships do not necessarily elicit valid and reliable responses, but do help in achieving the goals of the research. And no matter how objective informants may be, the researcher should recognize that informants can and do hold conflicting sentiments at one time and varying statements at another, according to the situations in which they find themselves; so there is no guarantee that informants' statements may be reliable.

Because most of the interviews were conducted face-to-face, it was important for notes to be written verbatim and *in situ*. Focus group interviews were held in the researcher's office as it was fairly easy to accommodate a relatively small group of four to five subjects.

4.2.2 Informed consent

For reasons cited above, the problem of informed consent to obtain access to teachers and schools was fairly simple to solve: it is part of the researcher's professional duty to visit schools to assess teachers on teaching practice placements. Thus, accessing teachers in schools was rendered simple as the researcher had good working relationships with school administrators and most members of the teaching community. However, in spite of the good rapport, it was valued ethical to inform interviewees and gatekeepers (namely, school administrators) of the principle of informed consent; though usually desirable, it was not necessary as the meetings with participants involved no danger or risk. The more serious the risk to participants, the greater becomes the obligation to obtain informed consent (Cohen *et al.*, 2000). The meetings with participants were conducted usually during lunch times and teachers' free periods, to avoid disrupting classes. The fieldwork involved repeated visits to schools and lasted as long as interviewing and collection of questionnaires were necessary to meet the objectives of the study.

4.3 Instrumentation

The naturalistic, interpretative paradigm of qualitative methodology uses multiple methods in an attempt to secure in-depth understanding of the phenomenon in question (Denzin & Lincoln, 1994). While not privileging a single methodology over any other, a variety of data collecting instruments were used in this study. In describing instrumentation, Miles and Huberman (1994) refer to specific methods for collecting data as being focused on qualitative or quantitative organized information, and may be loosely or tightly structured. Research instruments in this

study comprise data collecting tools such as questionnaires, interviews, focus group interviews, cohort study, content and curriculum analysis. These instruments are commonly used in developmental, ethnographic, and hermeneutic research within both qualitative and quantitative paradigms. At the same time, given the broad-based nature of the investigation, a multi-method approach has been utilized, with emphasis on interviewing, especially for the cohort study. With respect to interviewing, Bechhofer and Paterson (2000, p. 57) caution that

“a good rule of research design might be never to choose the interview as the main research tool until all alternatives have been carefully and, above all, imaginatively considered. In many cases it is unlikely that interviews would then be discarded altogether, but the frequently lauded but less often achieved goal of ‘data triangulation’ would result.”

The following sections provide a detailed description of the instruments used to collect data for this research study.

4.3.1 Questionnaires and questionnaire design

The design of questionnaires is an important consideration in any research study. As a data gathering instrument, it enhances the content validity of data by eliminating ambiguities and sharpening the focus of the survey by asking focus questions. In structured type questionnaires, questions are standardized with a common and transparent meaning (Bechhofer & Paterson, 2000). In general, structured questionnaires save respondents’ time, are ideal for asking factual matters, and are ideal for statistical descriptions. Because of problems of non-response (respondents cannot be coerced into completing a questionnaire) to certain structured questions, this study utilizes a combination of semi-structured and structured type questionnaires. A semi-structured questionnaire represents a compromise between structured and less structured questionnaire. Semi-structured questionnaires have both open and closed questions

While closed questions are quick to complete and straightforward to code for computer analysis, they do not enable respondents to add any remarks, qualifications and explanations to the categories. On the other hand, “open questions ... enable respondents to write a free response in their own terms, to explain and qualify their responses and avoid the limitations of pre-set categories of responses” (Cohen *et al.*, 2000, p. 248). Open-ended questions are at times too demanding of respondents’ time and are often left incomplete; they are in general difficult to code and to classify.

Attitudinal questionnaire items elicit responses that reflect the emotive or affective bent of individuals. Since variations in individual responses are the primary focus in this study, attitudinal questionnaire items have been used to validate responses. Two questionnaires A and B (see Appendices 8 and 9) have been designed to elicit data on the basis of Kirkpatrick four-level model (cited in Perry & Ball, 1997; Reeves & Hedberg, 2003) to evaluate training programs. Although described as an “overly simplistic” approach (Reeves & Hedberg, 2003, p. 177), in the absence of control groups and paper-and-pencil tests to measure knowledge and attitude, questionnaires designed on the basis of the four-level criteria (namely, learner reactions, learning, job behavior, and observable results) can provide valuable qualitative research data. At the first level, the questionnaire items are designed to measure participants’ reactions toward the program and its possibilities for learning. The second level (learning) is to gauge the extent to which participants change attitudes, improve knowledge, and/or increase skills as a result of participation in the program. Job behavior is seen by the extent to which behavior of trainees change in the workplace as a result of learning from the program. Finally, the fourth level (observable results) may be measured by the impact of training on results such as improved quality or return on investment. In this respect, the questionnaires contain a set of identical items (Questionnaire A: items B .. E; Questionnaire B: items 14 .. 17) to compare variations in individual responses.

4.4 Sampling respondents for Questionnaire A and Questionnaire B

The study employs two questionnaires: Questionnaire A and Questionnaire B. The subjects for filling questionnaire A were selected from the existing cohort of full-time pre-service trainee teachers, who were organized into four groups, each labeled as Red, Brown, Orange, and Green. The purpose of choosing the Brown group was to identify the learning needs of trainee teachers and to gauge the extent to which they felt the two-year preparation program was relevant and useful in preparing them to teach. It was felt that the group met the specific needs of this study as they could effectively provide answers to key questions A.2 and sub-questions A.2.2.- A.2.3 (section 1.11).

Respondents for Questionnaire B were sampled from a cohort of in-service teachers following upgrading courses on day-release, part-time basis at the MIE. A sample of 30 teachers was randomly selected from the cohort. Participants were mostly volunteers who

collected the questionnaires on their own free will. They were, however, informed of the aims and purposes of this study and the problem of bias associated with non-responses. The purpose of choosing this second sample was to seek the views and perception of experienced and veteran teachers of their past and present experiences on the 'subject teaching formula' of 1994, on their learning needs in the context of their own career development and the on-going reform in education. In the view of the researcher, the sample would meet the specific needs of this study in terms of effectively providing answers to the key research question A.1 and part of the sub-questions A.1.1 – A.1.4 (section 1.11). Questionnaire B (see Appendix 9) was designed to elicit these responses. The questionnaires were lengthy and needed not only a significant amount of time to fill but required careful and thoughtful reflection.

Both samples represented a homogeneous group of participants in terms of common demographic characteristics of age, education level, occupation, and income. Difference in ethnicity, gender and marital status were of minor significance and therefore inconsequential to the aims and purposes of the study. Selecting the Brown group represented both an opportunity sample as well as a purposive sample. An opportunity sample, because the members of the group were closest to the researcher who was directly responsible as their designated 'tutor.' The group was also regarded as a purposive sample because its members were believed to provide the data relevant to the research problems, and were thus selected on the basis of this prior identified criteria. The group was virtually 'handpicked' from the cohort (organized into four groups) and truly representative the cohort, because the choice of any another group would not bias the results, as each group received the same treatment in terms of lectures and tutorials.

The sampling method ensured the randomness of the sample even if it comprised a high proportion of female subjects, a factor that did not bias the findings as gender was not an issue in this research. The study did not necessitate a larger sample on the ground that a larger sample would have involved larger frequency counts, resulted in non-responses, and would have biased the results. Large frequency counts may lead to unwarranted generalizations and that was not intended in the study. Selecting a reasonably manageable sample size also meant narrowing the

focus of the investigation in order to make the comparisons between the different questionnaires items more conspicuous and transparent in the findings.

The 20-item Questionnaire A was administered to the 53 pre-service students of the Brown group. The questionnaire used structured question types with 3-point and 5-point Likert scales. It was felt that open-ended questionnaire items would provide too much latitude to respondents and responses would depend on the lucidity of individual participants and their ability to accede to and elucidate their own personal history. Whereas by furnishing items within a frame of reference and a format for the responses, the use of structured questions was intended to enhance the quality of the responses.

It should be observed that structured questions supply respondents with highly structured clues about the answers expected. Cicourel (1964) argues that the 'forced' character of responses severely restricts the possibility that the respondents' perception and interpretation of the items will be problematic. Through seeking to measure values, attitudes, norms and the like, questionnaire items define social scenes in hypothetical terms by imposing a deterministic 'grid' on the "emergent, innovational and problematic character of everyday life" (Cicourel, 1964, p. 113). However, the benefits of structured questionnaire items are that they produce an approach that finds through the respondent the salient surface characteristics of the social scene, without paying attention to the essential characteristics.

4.4.1 Analysis of Questionnaire A

Table 1 shows the majority of trainee teachers (81.1 %) are females, in the age-group 20-25 years , with 15.1 % graduates among females only. While 88.9 % of trainees have access to computers (Table. 2), 71.7 % own a computer, meaning that trainees, in their initial preparation phase, have access to computer facilities either at the training institution, a cybercafe, or home.

	Age		Gender		Graduate	
	Count	%	Count	%	Count	%
No						84.9%
Female				81.1%		15.1%
Male				18.9%		
20		1.9%				
21		18.9%				
22		34.0%				
23		17.0%				
24		9.4%				
25		9.4%				
26		3.8%				
27		1.9%				
28		1.9%				
31		1.9%				

Table 1. Distribution of trainees by age, gender and highest qualification

	Computer access		Own computer	
	Count	%	Count	%
No		11.1%		28.3%
Yes		88.9%		71.7%

Table 2. Distribution of trainees by access to computer facilities

Table 3 shows computed value of the Pearson's (product-moment) correlation coefficient ($r = .358$) between the development of written and spoken linguistic skills. The coefficient exceeds the table value $r_{.01} = .3541$ (see Cass, 1974, p. 257), with 50 degrees of freedom, thus establishing a significant correlation at 0.01 significance level. The degree of association, though not sufficiently high to explain causation, has a hidden correlate in gender – female teachers do better in language skills than males. The correlation coefficient between linguistic and communications skills (Table 4) are even higher when compared to written and spoken language skills. These data provide evidence to suggest that the language departments (English and French) provide adequate pedagogical content preparation to trainee teachers.

		Writing skills English/French	Spoken English/French
Writing skills English/French	Pearson Correlation Sig. (1-tailed) N		.358(**) .004
Spoken English/French	Pearson Correlation Sig. (1-tailed) N	.358(**) .004	

** Correlation is significant at the 0.01 level (1-tailed).

Table 3. Correlation between written and spoken language skills

		Spoken English/French	Communication skills
Spoken English/French	Pearson Correlation Sig. (1-tailed) N		.493(**) .000
Communication skills	Pearson Correlation Sig. (1-tailed) N	.493(**) .000	

** Correlation is significant at the 0.01 level (1-tailed).

Table 4. Correlation between linguistic and communication skills

Table 5 shows that over 85% of trainee teachers are confident in having acquired competencies in curriculum planning and organizing instruction. Nearly 13.5 % of respondents express feelings of uncertainty, a figure that tallies with the percentage of practicing teachers who think of changing profession. This may explicate the phenomenon that teachers who are dissatisfied or willing to change jobs are usually those who did not acquire adequate competencies during preparation phase of their career, so that the urge for changing jobs influence their classroom performance.

	Competencies in content-specific lesson plans		Competencies in primary curricula		Competencies to develop a coherent strategy		Competencies to set up groups	
	Count	%	Count	%	Count	%	Count	%
Disagree		2.0%				4.0%		4.1%
Agree		98.0%		85.7%		84.0%		75.5%
Not sure				14.3%		12.0%		20.4%

Table 5. Frequency table for curriculum planning and instruction

Table 6 shows frequency counts of responses in terms of competencies in assessing student performances. The table shows a high percentage of student teachers are confident about their knowledge and skills in managing assessment at classroom level; an average of 12.1 % responses evoke poor or inadequate preparation, the highest being in competencies relating to continuous assessment .

	Competencies in informative assessment		Competencies in summative assessment		Competencies in continuous assessment	
	Count	%	Count	%	Count	%
Disagree						4.1%
Agree		94.0%		90.0%		75.5%
Note sure		6.0%		10.0%		20.4%

Table 6. Bar Charts for competencies in assessment procedures

Table 7 shows Pareto’s Charts of two different instructional strategies (differential teaching and individualized instruction) in learning difficulties. The uneven endorsement of the charts means that teachers are not well prepared for the most challenging of classroom management tasks – diagnosing learning difficulties of children, meaning student teachers are inadequately prepared in inclusive pedagogy which has a component on diagnosing special needs children. Mastering these aspects of classroom management enable teachers identify disadvantaged and ‘low-ability’ children early for immediate remedial action. Actions comprise, in most cases, modifying the instructional approach to include differential teaching to enable the teacher select alternative strategies for children experiencing difficulties, or to attend to children on an individual basis (individualization) to understand their problems and find solutions.

6.4 % of respondents are unaware of how to organize and implement group work. This apparent discrepancy may be linked to teacher program deficiencies in areas of inclusive pedagogy and special needs of children. To account for these problems, it can be argued that a training program predicated on the use of familiar knowledge (subject matter knowledge) and unfamiliar forms of knowledge (pedagogical content knowledge, and propositional knowledge) define the zone of proximal development (Vygotsky, 1978) that may inhibit rather than enhance learning.

	Differential Teaching		Individualized Instruction		Collaborative Group Work	
	Count	%	Count	%	Count	%
Disagree		8.0%		4.0%		2.0%
Agree		68.0%		80.0%		76.0%
Note sure		24.0%		16.0%		22.0%

Table 7. Frequency counts for diagnostic of learning

Figure 1 shows a high proportion of teachers (56.8 %) being unaware of the skills required for classroom management, at the end of two years of professional preparation. A shortcoming of this magnitude in professional preparation bears significantly on the pedagogical performance of novice teachers. Does the data on teachers’ knowledge in classroom management correlate with the high drop-outs and low performance in our schools?

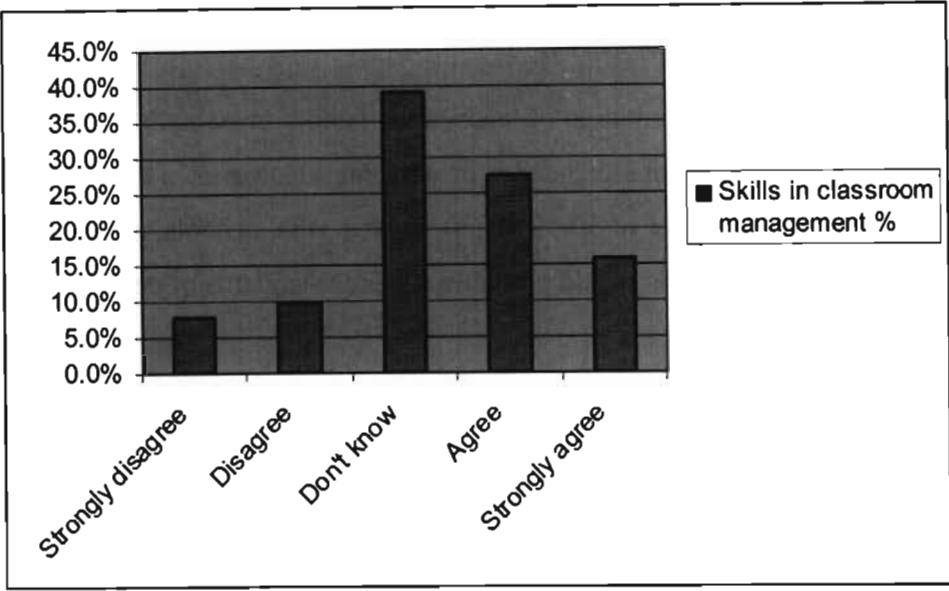


Figure 1. Skills in classroom management

Table 8 shows that the course in Information and Communications Technology (ICT) was often distressing to the new teachers. 68.6 % had initial difficulties and /or negative perceptions of computer literacy courses. The negative perception category includes 25. 5 % teachers who disagree being labeled computer literate, while 43.1 % disagree having learnt any computer skills during their professional preparation.

	Computer skills
	Percentage
Strongly disagree	17.6%
Disagree	25.5%
Don't know	25.5%
Agree	19.6%
Strongly agree	11.8%
Total	100.0%

Table 8. Frequency table for computer literacy

4.5.1 Analysis of Questionnaire B

Table 9 shows the distribution of teachers by gender in schools in rural and urban areas. The distribution in terms of gender is uniform. However, a high percentage of male teachers (in age bracket of 50-59 years) work in rural schools, meaning that experienced teachers in rural schools would probably enhance standards or perpetuate the *status quo*.

		School region	
		Rural	Urban
Age Group	30-39 years		
	40-49 years		
	50-59 years		
Teaching experience	10		
	11		
	12		
	14		
	15		
	18		
	25		
	26		
	27		
	28		
	29		
	30		
	31		
	40		
Gender	Female		
	Male		

Table 9. Distribution of teachers in rural and urban schools

The Pareto Chart of Figure 2 shows that teaching of basic mathematical concepts are based on textbooks developed by the MIE in collaboration with Mauritian National Centre for Curriculum Research and Development (NCCRD). The uneven endorsement of the charts means that teachers have inadequate preparation in the pedagogy of elementary mathematics education, especially in the need for craft knowledge to teach concept formation.

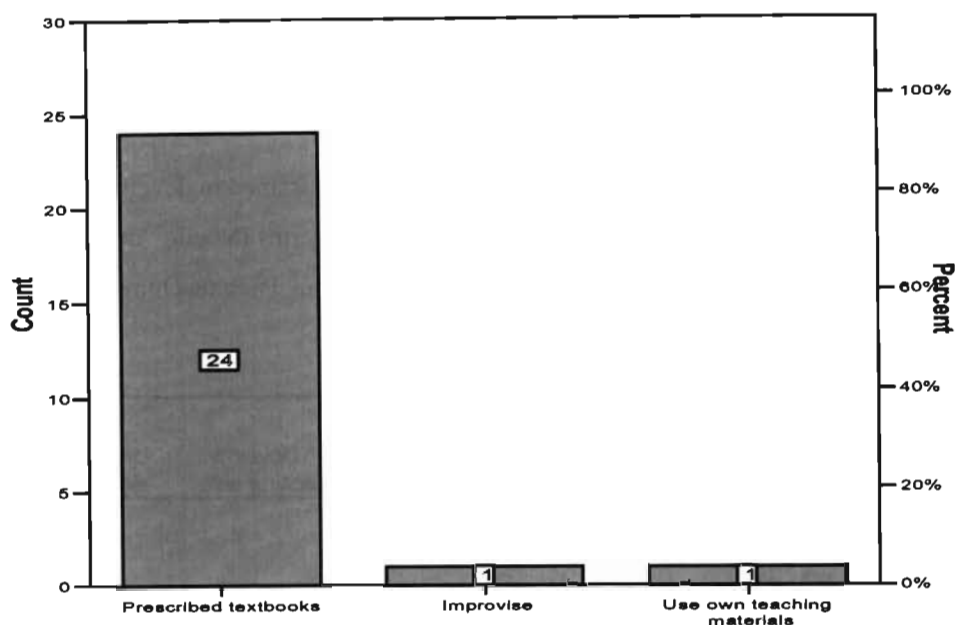


Figure 2. Pareto Chart for mathematical concept teaching

Table 10 shows positive correlation coefficient ($r = .507$) between effective teaching of mathematics in lower and upper primary in relation to the preparation program offered by MIE. The correlation coefficient exceeds the table value $r_{.01} = .4869$ (see Cass, 1974, p. 257), with 25 degrees of freedom, thus establishing correlation at 0.01 significance level. The hidden correlate is the dependency teachers build on using prescribed textbooks produced by the Department of Mathematics Education of the MIE (under the aegis of the National Centre for Curriculum Research and Development - NCCRD). The figures provide evidence to suggest that elementary mathematics curriculum materials determine to a large extent teachers' behaviors and classroom practice.

		Teach maths in Lower Primary	Teach maths in Upper Primary
Teach maths in Lower Primary	Pearson Correlation Sig. (1-tailed) N		.507(**) .004
Teach maths in Upper Primary	Pearson Correlation Sig. (1-tailed) N	.507(**) .004	

** Correlation is significant at the 0.01 level (1-tailed).

Table 10. Correlations between teaching mathematics in Lower and Upper Primary

Table 11 shows low correlation between teachers being trained in developing and in using teaching aids. It reflects the quality of preparation programs in being deficient in practical aspects of classroom instructions, namely developing and using teaching aids efficiently.

		Develop teaching aids	Use teaching aids effectively
Develop teaching aids	Pearson Correlation		.057
	Sig. (1-tailed)		.392
	N		
Use teaching aids effectively	Pearson Correlation	.057	
	Sig. (1-tailed)	.392	
	N		

Table 11. Correlations between development and use of teaching aids

Items 14 – 17 (section B,C,D,E) of Questionnaire B (intended for practicing teachers) are identical to those of Questionnaire A (intended for beginning teachers). The aim is to compare student teachers' and seasoned teachers' perceptions of their preparation program and work experiences in respect of communication skills, curriculum, student evaluation and diagnostic of learning difficulties. Table 12 shows a high proportion of disagreement in teachers having adequate skills and competencies in assessing student performance. This apparent discrepancy may be partly attributed to low profile accorded to assessment techniques and procedures. The emphasis in preparation programs is on honing content (subject matter knowledge) for transfer to classrooms. Preparation of teachers in the 1960s and 1970s favored such an approach.

	Competence formative assessment		Competence in summative assessment		Competence in continuous assessment	
	Count	%	Count	%	Count	%
Agree		65.4%		65.4%		69.2%
Disagree		34.6%		34.6%		30.8%

Table 12. Frequency table for competencies in assessment

The worst results in the survey of teachers with regard to skills in diagnosing learning difficulties of children and finding an appropriate approach to deal with special need problems are shown in Table 13. It is obvious that this aspect of special education needs is not adequately addressed in teacher preparation programs. As a result teachers are unable to identify low-ability students and take timely, appropriate action. These may have implications in problems of drop-out. ‘Low ability’ children are usually relegated to the back benches of classrooms, indicating that they are the potential drop-outs.

	Differential Teaching		Individualized Instruction		Collaborative Group Work	
	Count	%	Count	%	Count	%
Agree		37.0%		38.5%		34.6%
Disagree		51.9%		50.0%		53.8%
Don't know		11.1%		11.5%		11.5%

Table 13. Frequency counts for diagnostic of learning

Figure 3 highlights the issue of classroom management as being inadequately addressed or completely overlooked in preparation programs. The graph reveals that the majority of even experienced teachers are generally inept in classroom management.

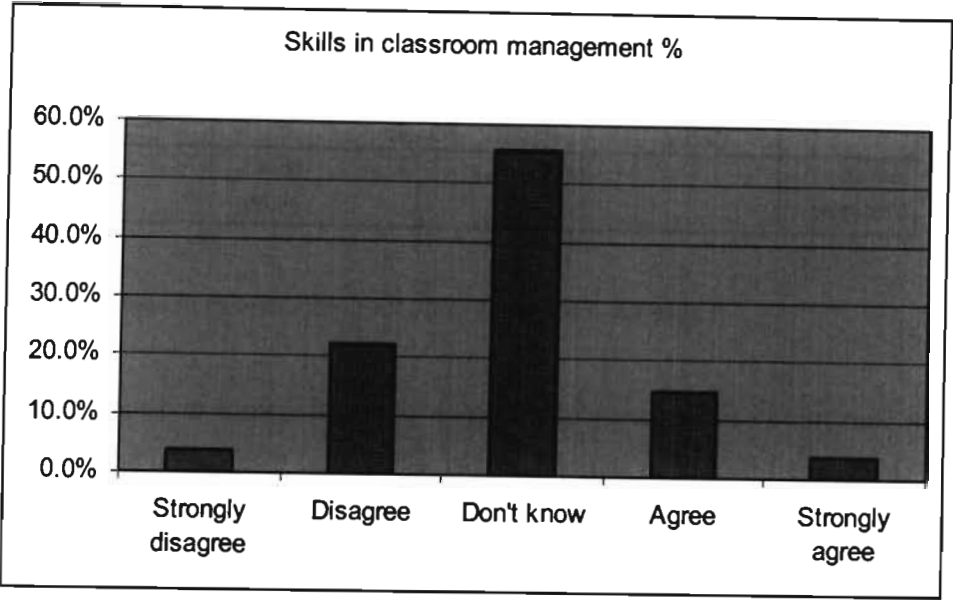


Figure 3. Bar charts for skills in classroom management

Table 14 shows 74.1 % of experienced teachers agree on the impact of preparation programs in their classroom practice. While 69.2 % agree on using discovery methods for concept formation, only 38.5 % rely on textbooks for most of their classroom teaching.

	TCP influences instruction		Use Prescribed textbooks		Use discovery method	
	Count	%	Count	%	Count	%
Disagree		3.7%		3.8%		
Don't know		7.4%		7.7%		26.9%
Agree		74.1%		38.5%		69.2%
Strongly agree		14.8%		50.0%		3.8%

Table 14. Distribution of responses on impact of preparation program

The multiple bar charts of Figure 4 show the effectiveness of student teachers' preparation programs having a higher focus in developing lesson plans focused for classroom use than experienced teachers who relied on their subject matter knowledge for classroom practice. However, teaching experience determines to a large extent teachers' competencies in curriculum matters, cooperative learning and planning classroom practice. Most trainees agree that they

acquired the basic competencies in curriculum planning and instruction and understood most aspects of the content of primary curriculum. This explains that the initial phase of the training coincides with their professional maturation in the behavioral, cognitive and moral development. They show interests in their initial commitment to teaching in terms of curriculum planning and instruction, student evaluation, classroom management, and development of linguistic skills.

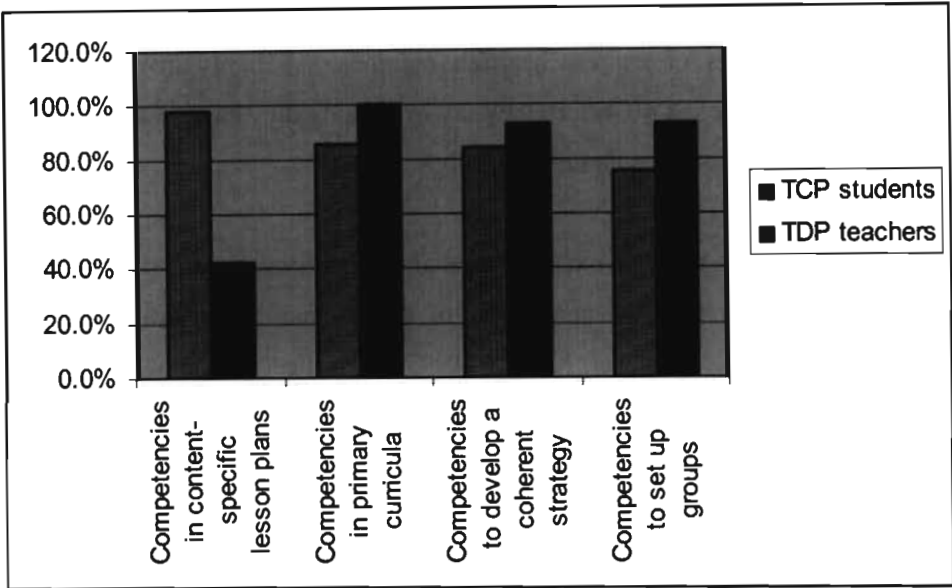


Figure 4. Comparing novice and experienced teachers’ competencies

4.6 Focus group interviews

The basis of the investigation was a series of two focus group interviews conducted by the researcher with a sample of four teachers from the first sample of 53 student teachers who had filled Questionnaire A. The four participants comprising the samples were volunteers who agreed to meet the researcher in separate groups for the focus group interviews. The interview was held in the researcher’s office and the participants agreed that the interview would be recorded verbatim, in their presence. The interview lasted between forty-five minutes to one hour, depending on how much the respondents could unveil on their training.

According to Morgan (1993), a focus group interview is a form of interview involving a group of six to eight persons on a specific topic. The method singularly differentiates itself from group interviews because of its focus on a specific topic for discussions, but has commonalities when considered that both methods belong to the domain of talk and social interaction. Group size is

an important consideration for conducting focus groups as the researcher must strike a balance between having enough people to generate a discussion, or not having as many people so as to compel a contribution just to keep going. Morgan (1993) recommends a typical group to comprise six to ten people, but nonetheless acknowledges that groups with fewer than six is possible, depending on the degree of participants' involvement, the complexity of the topic, and the project goal of getting in-depth understanding of what participants have to say. Morgan (1993, p. 73) argues that "having fewer participants (less than six) gives each one more time to tell personal stories or express heartfelt opinions. ... Highly involved participants will get frustrated if they are cut off before they say everything they have to say; smaller groups increase their opportunity to express themselves fully."

The study chose the latter option (i.e. less than six participants) as it is felt that a smaller number is a safer approach from the perspective of group dynamics to deal with highly emotional or controversial issues. However, Morgan (1993) advocates the use of smaller groups as it allows the researcher to hear more from each participant, enables the researcher to schedule people more easily to be in the same place and at the same time. The choice of smaller groups also eliminates the 'groupthink'¹ effect where each member of the group attempts to conform his or her opinion to what they believe to be the consensus of the group, while individually a member might normally dissent from the group (Wikipedia). Focus groups are usually characteristics of the attributes of group dynamics in expecting groups to go through four main phases: *forming* (pretending to get on); *storming* (knowing they don't get on and being angry); *norming* (getting used to each other); and *performing* (working in a group to a common goal) (Wikipedia).

Another issue influencing focus group interviews is the number of groups needed for a particular topic. Morgan (1993) recommends that the number of groups could be in the range three to five to the extent that each additional group would have a diminishing return while increasing the number of groups tend to make groups become repetitive so that the stage of 'theoretical saturation'² is reached fairly quickly. To maintain the balance between diminishing return and 'theoretical saturation', the researcher in this study chose two groups for this type of interview.

¹ Groupthink has been cited as a contributing factor in the disasters of space shuttles Challenger and Columbia, and lately in the decision to go to war in Iraq in 2003 (Wikipedia)

² Theoretical saturation is a stage where no further gains in new information is obtained even on further increasing the number groups. (The concept was introduced by Glaser and Strauss.)

4.6.1 Sampling participants for focus groups

According to Morgan (1993), there are many potential methods³ for selecting participants for focus group interviews. Group composition is crucial to the overall success of the approach. Morgan (1993, p. 55) cautions that “the right group composition will generate free-flowing discussions that contain useful data, (while) the wrong group composition may bring together people who have little to say to each other or who may carry on lively conversations that have little relevance to your needs and goals.” The selection criteria for participants are based on the purposiveness and homogeneity of participants which are the main performance indicators linked to the project’s goal and the overall success of focus groups. A purposive sampling strategy focuses on participants according to the project’s goals, while the homogeneity criterion ensures compatible participants (i.e. having common interests and same profession, as in this study) – both factors are important considerations in promoting productive discussions. “Mixed groups may spend a good of time getting to know each other and building trust before they feel safe enough to share personal information – if they ever reach this level of comfort” (Morgan, 1993, p. 59).

Among the different methods currently used for locating participants, the researcher chose intercept sampling to build the focus groups for this study. According to Morgan (1993), intercept sampling is based on finding participants at a location where the focus group is held. The participants were conveniently sampled as there were two different cohorts of teachers attending upgrade programs and were intercepted almost every week to form the focus groups. The recruiting strategy involved intercepting the potential participants during lunch breaks or stealing time out of lecture time to ‘piggyback’ them into the researcher’s focus group.

The selection criteria for group composition was to ensure homogeneity of groups. A group of four participants was constituted from the cohort of pre-service teachers, a single participant being selected from each group. Each participant had common educational background and demographic characteristics. They were given pseudonyms in view of the confidentiality of the surveys; they were Wendy, Sharon, Pamela, and Karen (see Appendix 10).

³ These include existing lists, random sampling, referrals, intercepts, and open solicitation.

4.6.2 Analysis of focus group interview data

To analyze conversational interview data, the researcher utilized the QSR⁴ NVIVO software. NVIVO is a case tool for qualitative data analysis. The approach is based around organizing the conversational data into two analysis formats: case or cross-case. The case analysis approach requires writing a case study for each interviewee as a project document, while the cross-case approach would mean grouping together 'documents' from different data sources to common questions and analyzing the different perspectives on central issues. The software utilizes electronic-based research to highlight ideas that can be linked and compared with patterns across documents and the results saved, printed, undone at will. NVIVO organizes raw data (interviews, observations, etc.) and links them with memos and "databites" with which researchers make codes and analytical notes, and then edit and rework ideas as the project progresses.

The first decision to make is which approach to be used. The researcher chose the cross-case method to group together interviewee documents from different pre-service teachers to a common question based on the effectiveness of their preparation programs with respect to their level of preparedness to teach elementary school mathematics (Appendix 10).

The NVIVO analysis results are displayed as networks (Network 1 below) represented by 'nodes' linked with directional/bi-directional arrows. The nodes are labeled with blocks of short texts, representing the conceptual variables in the interview data. Conceptual variables common to the different data sources (documents) are linked with bi-directional arrows to show common perceptions, while nodes with at least two bi-directional arrows display conceptual clustering and provide concurrent validity to responses from different data sources.

The network display (Network 1, Figure 5) has 15 'nodes' put together in cross-case format. Variables with at least two converging arrows represent conceptual clustering and share important attributes in providing causal explanations. The clusterings reveal some positive as well as negative points about the preparation program and the level of preparedness of trainee teachers

⁴ QSR = Qualitative Solutions and Research International.

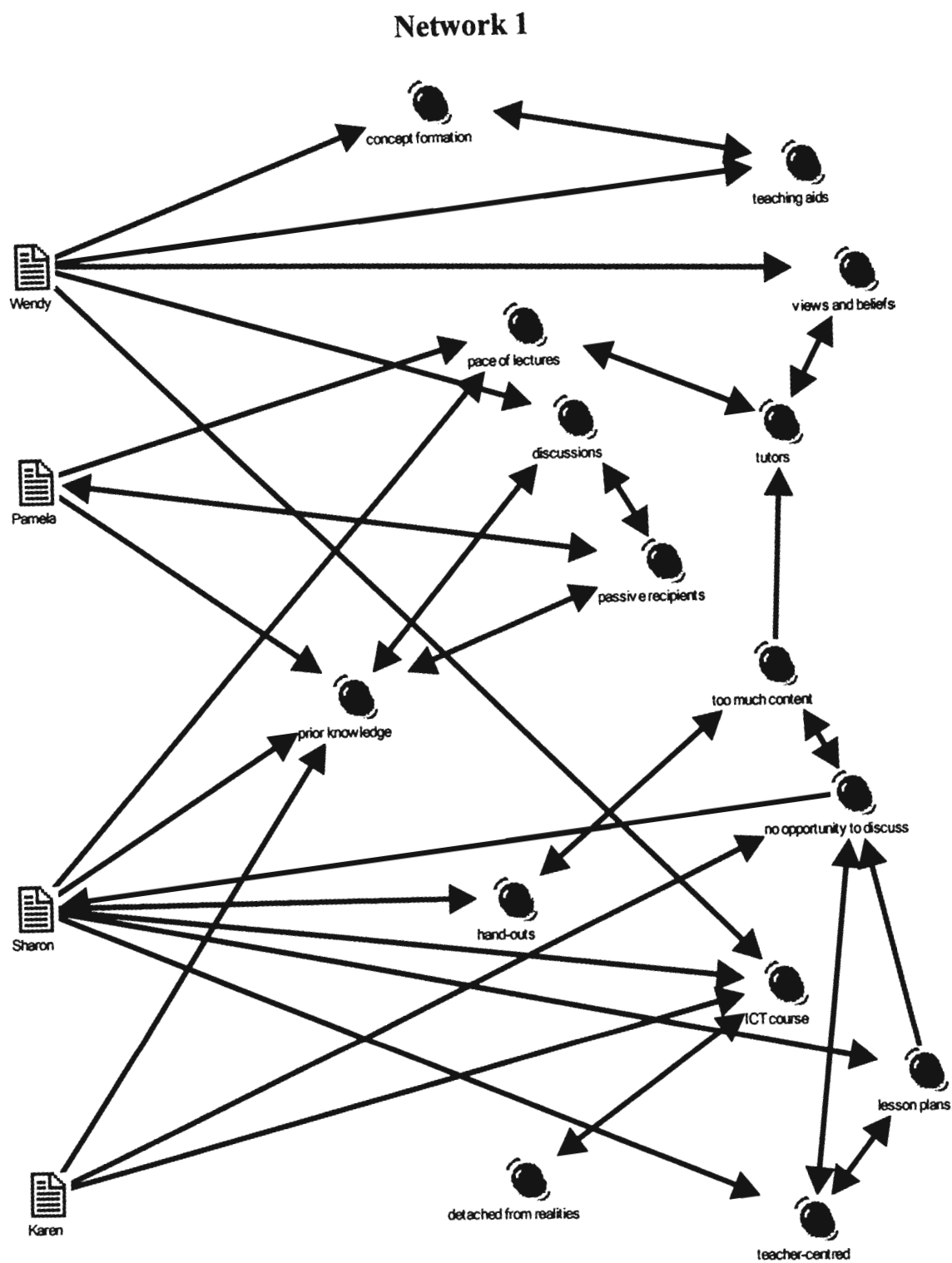


Figure 5. Network display of 'Effectiveness of preparation program'

The cross-case analysis provided the following information:

1. There is general consensus about the pace of lectures and the face-to-face approach used. All participants considered the lectures to be too fast that they were teacher-centered, with views of the lecturers dominating the discussions. Prior knowledge of trainee were hardly ever tapped either in discussions or by lecturers who were more concerned with their own views and beliefs about content and pedagogy than the learners. Teaching aids were found to be useful for development of mathematical concepts, but some were considered to be far-fetched and unrealistic in the context of lower primary classes. One of the interviewees supported her argument from a lesson plan in which a 'paper heart' was used to model a lesson in line symmetry. Use of such abstract approaches to model reality was regarded as a major weakness of the preparation programs.
2. Of particular concern was the pace of lectures. The interviewees found that their individual differences in their ability to keep up with pace of lectures and understand what was being presented were all too often ignored. Trainees were regarded as passive recipients and had no opportunity to discuss or reflect on their courses.
3. On the strategy of supplementing lecture notes with hand-outs, some student teachers regarded hand-outs as relevant and valuable materials that were dished out in lieu of lecture notes. Some would question the relevance and content validity of hand-outs with regard to examination relevance. Often hand-outs were not read at all and there no way to assess the content and usefulness of hand-outs. Some believed that lectures formed the most valuable part of instruction: only side information of minor importance was dished out as hand-outs as a device to ease the tutor's tasks. Some considered that the content of hand-outs had no relevance in their final preparations for examinations. For the most part, they did not read the hand-outs
4. The discussion method appears to be prioritized during tutorials. While trainees were given ample opportunities to discuss the instructors' views and approaches, there was discontent about trainees bringing in their own views. Lecture time schedules restricted open discussions that tended to be too long for the allocated time.

5. Courses in Information and Communications Technology (ICT) seem to be most detached from the realities of classroom instruction. While most trainees prefer ICT to be applied to promote constructivist teaching and learning through investigation and exploration of basic concepts in elementary mathematics, they were disillusioned by the emphasis on learning about computers and their applications.

4.7 Informal conversational interviews

According to Patton (1990), informal conversational interview is the most open-ended approach to interviewing. "The conversational interviewer wants to maintain maximum flexibility to be able to pursue information in whatever direction appears to be appropriate, depending on what emerges ... from talking to one or more individuals in that setting. Most of the questions will flow from the immediate context. ... No pre-determined set of questions is possible... because the evaluator does not know beforehand what is going to happen or what will be important task" (p. 281).

The approach ensures the data gathered will be different for each person interviewed and that the same person is interviewed on different occasions. Patton (1990) observes that the conversational interviewer must 'go with the flow,' meaning that the people being interviewed may not know in the course of the informal conversation that the purpose of the conversation is to collect data. In this situation note-taking occurs after the 'conversation', though in this study the researcher did take notes while the informal conversation was on-going. The challenges facing the conversational interviewer, as it happened in this study, were the ability to interact with people being 'conversed' with, formulate questions quickly, and take notes verbatim.

However, interviewing is not without its own problematic. Dean and Whyte (1978) point out that researchers dealing with interview data frequently are asked the question: 'How do you know if the informant is telling the truth?' Statement of respondents can vary purely from subjective statements to almost completely objective statements depending upon the time and circumstances of the interview. The researcher adopted a strategy whereby interview questions were changed over time, and each new interview was built on those already done, expanding information that was picked up previously, moving in new directions, and seeking elucidations and elaborations from other participants.

Patton (1990) further argues that the strength of the approach lies in the researcher's ability to be highly responsive to individual differences and situational changes. Questions can be individualized to probe for in-depth communication with the person being interviewed. The weakness of the method is that it takes a greater amount of time to collect systematic information; the method is prone to interviewer effects.

Interview questions were fairly open type for each interviewee with the objective to probe deeper in order to validate data from focus groups and questionnaires. The informal interviews were not regarded as a separate exercise for their own sake but could be associated with and were complementary to the objectives set out in the other two instruments, namely questionnaires. Cohen *et al.*, (1998, p. 121) describe this type of comparison as "convergent validity" because it tends to minimize bias as far as possible. Leading questions were avoided as these tend to make assumptions about interviewees and often influence the answers illegitimately (Cohen *et al.*, 1998).

4.7.1 Sampling participants for informal conversational interviews

The strategy of sampling key informants for informal conversational interviews is based on a combination of maximum variation sampling (Patton, 1990; Miles & Huberman, 1994) and Johnson's dimension sampling (cited in Miles & Huberman, 1994). The maximum variation sampling is a sampling strategy aimed at selecting outlier cases in a heterogeneous sample with the purpose to find common patterns emerging from great variation in experience. The sample is considered heterogeneous as it is made up of a head teacher, a senior teacher and a government primary school inspector, each having different and great variation in the field of primary school education (see Appendix 13). In the latter sampling approach, the researcher lays out the dimensions on which variability is sought, then takes 'well-informed' informants for each contrasting dimension. The aim of taking a mix of two sampling strategies is not to generalize findings but to look for information that elucidates programmatic variations and significant patterns within that variation (Patton, 1990). The intended aim is to find people who are knowledgeable, reliable, and accurate in reporting events that are usual, frequent, or patterned.

The sample chosen is relatively small compared to the other samples. The logic for using small samples with high variations among participants is that: "any common patterns that emerge from

great variation are of particular interest and value in capturing the core experience and central, shared aspects or impacts of a program” (Patton, 1990, p. 172).

4.7.2 Analysis of informal conversational interview data

NVIVO software was again used to analyze the informal conversational data. A cross-case analysis approach was used to organize the conversational data into documents (see Appendix 13) for each participant who had different experiences in elementary school education. In analyzing the data from the informal conversational interviews, the researcher searched responses to find patterns emerging at different points in the interviews. These are represented as nodes in Network 2 (Figure 6). The network has 22 nodes linked with block of texts constituting the conversation. Variables showing conceptual clustering provide the basis on which the conversations were mostly focused. Four conceptual clusterings were prominent from the network on the following issues: 1) new social order; 2) societal call for curriculum innovation; 3) reform in mathematics education; and 4) technology-based instruction.

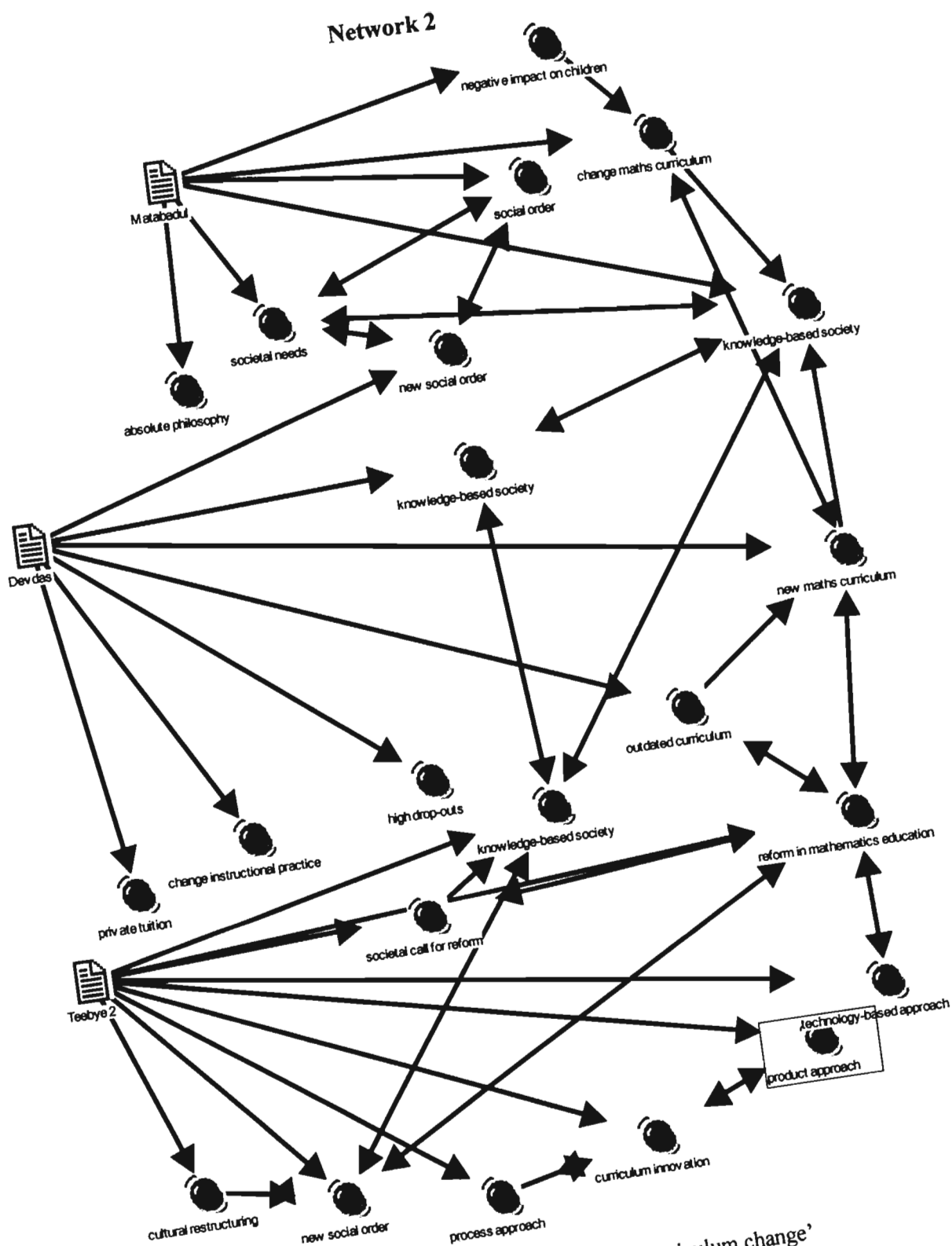


Figure 6: Network display of 'need for curriculum change'

1. New social order. Participants are aware of the need for a new social order that is spurred by the information age and by the current drive towards a knowledge-based society. Society calls for a reform in education, for a redefinition of school curriculum. The current curriculum is based on absolutist philosophies. There is a need to move towards a new philosophy that can bring a fundamental restructuring of the entire learning environment.

2. Societal call for curriculum innovation. Teachers regard the present school curriculum as outdated. It cannot be used to prepare children to be the next generation of adults of the information age. The common perception is that the curriculum has nourished private tuition, drop-outs and inequity in terms of learning opportunities for all. There is wide consensus around society's call for reform that includes transforming the school curriculum to reflect the needs of a new society spurred by the information age.

3. Reform in mathematics education. The structure of elementary school mathematics is based on absolutist philosophies which has generated stereotyping. Teachers show no interest in innovative ways of teaching mathematics. They still resort to their repertoires of lesson plans from training institutions. The transmission model of education must give way to social constructivists approaches in a process to transform content, modes of instruction, and methods of assessment.

4. Technology based education. There is general consensus that elementary school mathematics must be redesigned to reflect the needs of the information age. The traditional learning style must change to integrate social constructivist orientations so as to provide new dimensions to mathematics education. More emphasis on process of mathematics. The importance of integrating computer technology into mathematics education and the need for a global curriculum are emphasized.

4.8 Triangulation

Although interviewing is often regarded as invading people's privacy or demanding too much of people's time (Bechhofer & Paterson, 2000), interviewing in this study takes the form of a conversation analysis having a tenuous connection with ethnomethodological practice. The point of departure is to look at the process of interviewing as being always concerned with the domain of talk and social interaction, emphasizing discourse-in-context as a means of building context and meaning (Holstein & Gubrium, 1994). From an ethnomethodological standpoint, interviewing

as a situated context for naturally occurring discourse provides the means for building context and meaning. Interviewees see naturally occurring discourse as constitutive of a domain to share views and opinions which would otherwise be difficult. Interviewing in this sense is used in this study as a strong form of triangulation³ to strengthen particular aspect of the domain of talk and social interaction resulting from focus group interviews as well as data collected from questionnaires.

Triangulation as a research technique is used to strengthen a study design. In this study, the informal conversational interviewing is used as a mixed methodology strategy of holistic-inductive (qualitative/naturalistic) paradigm to validate and strengthen data already collected through questionnaires and focus group interviews. According to Denzin (quoted in Patton, 1990, p. 187), the logic of triangulation is based on the premise that

“no single method ever adequately solves the problem of rival causal factors.... Because each method reveals different aspects of empirical reality, multiple methods of observations must be employed. This is termed triangulation. I now offer as a final methodological rule the principle that multiple methods should be used in every investigation.”

Triangulation of questionnaire data through interviews foregrounds any hidden shortcomings or attributes - preparation program deficiencies, teachers' knowledge, skills, curricular problems, etc. These were be evidenced through questionnaires and validated through interviews

4.9 Analysis of elementary school mathematics texts

One of the aims of this study is to perform content analysis of mandated elementary mathematics textbooks to investigate the nature of elementary mathematics instruction, student performance expectations, and perspectives encouraged. Unlike curriculum analysis which is often based on the Tylerian approach of matching curriculum objectives with learning outcomes, in this study content analysis differentiates itself from the methods of curriculum analysis. In this study, content analysis is based on 'pedagogical evaluation' of the content of mathematics textbooks with respect to cognitive indicators. The process entails setting up indicator (empirical) variables in respect of specific concept (theoretical) variables. Concept variables are regarded as cognitive indicators in the study of mathematics. These include (a) critical thinking skills which involve

processes of problem-solving, communications, and reasoning; and (b) use of progressive mathematization, bridging (through situational modeling), guided discovery, and visualization. The latter criteria are borrowed from Realistic Mathematics Education (RME)⁴ (see section 7.4, chapter 2). RME is regarded as “a domain-specific instruction theory for mathematics education” (Heuvel-Panhuizen, 2003, p. 9). Table 15 shows the cognitive variables organized as concept and indicator variables.

Concept variables	Indicator variables
Critical thinking	<ul style="list-style-type: none"> • Problem-solving • Connections/communications • Reasoning
Realistic mathematics education	<ul style="list-style-type: none"> • Progressive (or applied) mathematizatio • Guided discovery • Bridging • Visualization

Table 15. Cognitive variables expressed as concept and indicator variables

To analyze the content of the elementary mathematics textbooks, a sample of topics from the mandated elementary school mathematics curriculum were analyzed and researched following Gagné’s task analysis approach (Romberg & Carpenter, 1986). The approach provides a framework for systematically organizing a content domain into a hierarchy of principles, concepts, and skills. The criteria of selection is based on the researcher’s experience of mathematics instructions in teacher preparation programs that have been the most problematic in terms of craft knowledge (pedagogy). The topics will not be differentiated as belonging to particular levels of the primary curriculum since topics introduced in lower primary are carried over to be further developed (scaffolded) in upper primary levels. The topics being most problematic are: concept development with respect to application of set-theoric notation, long

⁴ This theory is the Dutch answer to the need, felt worldwide, to reform the teaching of mathematics. The concept of RME is due to H. Freudenthal (<http://www.geocities.com/ratuilma/rme.html>). Briefly, RME is based on the idea that, for mathematics to be of human value, it must be connected to reality, stay close to children and should be relevant to society. The theory advocates that children learn mathematics by developing and applying mathematical concepts and tools in daily-life problem situations that make sense to them. The theory is related to constructivism through strands germane to mathematics education, viz. radical constructivism, social constructivism, and socio constructivism. (Accessed 12 March 2004).

division, geometry, rational numbers and strategies for solving problems (word problems, survey problems, etc.).

1. Sets and sets theory

The concept of sets and sets theory form an integral part of the upper primary mathematics curriculum. Although it cannot be denied that some familiarity with the notation and language of sets is useful and important in concept formation at the lower primary level, the emphasis on formal theory of sets in Standard V (p. 40-46) and Standard VI (p. 39-49) is unwarranted given the nature of sets that is based on logical reasoning with Venn diagrams. The notion of sets and set theory is conceptualized by most educationalists as an abstract subject. Its use in lower primary represents a premature utilization of symbols (Venn diagrams, union, intersection, element of , etc.) in a conceptualization that relates concrete objects with abstract symbols. Although initially designed to be used to model elementary arithmetic operations of addition, subtract, division, and multiplication, the emphasis on sets have been extended to logico-mathematical operations and modeling of survey problems. Instead of exploiting and cultivating children's informal counting skills, which is considered an essential aspect of the development of early number concepts (Payne & Huinker, 1993, cited in Verschaffel & De Corte, 1996), application of set theory to logical operations leads to a direction towards the abstract and denies children their natural propensity to apply their number sense.

It should be realized that even a broad initiation to formal theory of sets may be premature at this stage to develop formal operational thinking in 10-11 year olds as advocated in Piaget's cognitive development theory. In solving problems with sets symbols and notation, the problem of motor skill in execution becomes entangled with those of conceptual understanding (Freeman 1980, cited in Langford, 1987). Bruner (cited in Hodgkin, 1985) reminds that the cognitive and motor skills which children bring to these problems are partly innate and partly learnt and that a failure by a child to allow for it in communication is a frequent cause of educational failure.

2. Problem solving

A study of the upper primary mathematics curriculum reveals that the main focus in the Standard IV-VI mandated curricula is on the development of problem solving skills. The first chapter on 'Numeration and notation' of the Standard VI textbook uses a single illustrative example on solving problems relating to addition, subtraction, multiplication, and division, while the subsection on 'number problems' (p. 21) consists of a set of sixteen word problems for the

students to solve unassisted. In the absence of teachers' guides and inadequate model solutions, teachers and pupils are left to their own devices to use heuristic or common sense or trial and error methods to find a workable strategy that produces the 'correct answer' (answers are not provided).

For example, to introduce the concept of long division, the writers of the curriculum materials most often use a common division algorithm (Standard VI, p. 18), more apt for able learners, than developing the approach progressively through the processes of estimation or using 'division as repeated subtraction.' The problem with the division algorithm is that it involves a number of guesses before a person finds the correct answer (Wheeler & Wheeler, 1995). The authors go a step further by associating long division with word problems involving stereotyped computational problems based on solving for 'How many.' 'How many' is usually a question of numerosity (Sowder, 1992, p. 371) and the typical procedure used in numerosity computation is to proceed systematically from estimation to long division, an approach that entails little variations in the procedure. The case in point is that the curriculum encourages teachers to operate in the mode of a technical rationalist (Schön, 1986) who resorts to the '*artillerie lourde*' (see section 2.5) rather than applying a pedagogy of craft knowledge based on 'progressive mathematization' (see section 7.4). The algorithmic solution to problem solving is prioritized over more practical methods (heuristic, Polya four-step method, forward chaining, backward chaining, modeling, and information processing approach – see Figure 9). Langford (1987) suggests an alternative view of problem solving taken by information processing theory, which has been the most popular approach to this topic in recent years. The approach assumes a mental solution in order to remember the information given. This is called the knowledge base. This is then acted upon by problem-solving strategies.

There is a growing body of research that suggests that children invent a great deal of their own mathematics and that they come to school with well developed informal systems of mathematics (Resnick 1976, cited in Romberg & Carpenter, 1986). Children's strategies are frequently more efficient and more conceptually developed than the mechanical procedures dictated by teaching. As children progress in solving word problems, they develop more abstract versions of their models. Children's invented strategies at conceptualizing problem solving suggest that the current primary mathematics curriculum fails to capitalize on the rich informal mathematics that children bring to instruction.

Schoenfeld (1992) reports that problem solving has been used with multiple meanings, ranging from working rote exercises to doing mathematics as a professional. Children solve word problems by counting (Romberg & Carpenter, 1986). For most problems, they tend to associate logico-mathematical operations with physical numbers in word problems, without regard to the semantic structure of the problem. Riley *et al.* (1983, cited in Romberg & Carpenter, 1986) identified three basic levels of knowledge involved in problem solving: (i) problem schemata, (ii) action schemata, and (iii) strategic knowledge for planning solutions to problems. Though all the three levels are equally important and used, it is found that most children use level 3 to invent their own strategies for solving word problems. It is argued that children, on the basis of empirical evidence, actively construct knowledge for themselves through interaction with the environment and reorganization of their own mental constructs. Resnick (1987) suggests that children invent a great deal of their own mathematics and that they come to school with well-developed informal systems of mathematics. Romberg and Carpenter (1986, p. 853) posit that “children are not passive recipients of knowledge; they interpret it, put structure into it, and assimilate it in light of their own mental framework.” The following classroom exchange, recently observed by the researcher, would appear to substantiate these arguments. An 11-year-old child from a rural school used a ‘modeling approach’ to solve the following word problem:

After spending $\frac{1}{4}$ of his money, Anil had Rs 9.00 left. How much money did Anil have at first.

Solution strategy: The strategy employed is based on the concept of bridging that entails modeling the solution using the semantic structure of the problem (see Figure. 5)

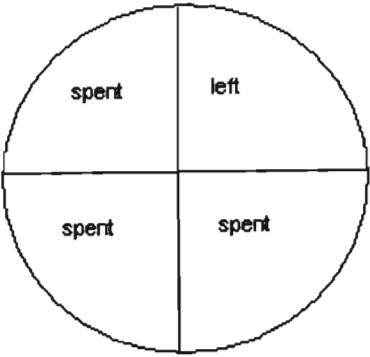


Figure 5

$\frac{3}{4}$ of the whole = Rs 9.00. The whole = $9.00 \times \frac{4}{3}$ = Rs 12.00

Common errors are: $\frac{1}{4} \times 9.00 = \text{Rs } 2.25$.

In its 1980 *Yearbook*, the National Council of Teachers of Mathematics (NCTM 1980, quoted in Schoenfeld, 1992) made problem solving a major theme of school mathematics during the 1980s. A decade later, other publications of the U.S. National Research Council, (namely *Every Counts*, 1989, cited in Schoenfeld, 1992)) and the National Council of Teachers of Mathematics (*Curriculum and Evaluation Standards for School Mathematics*, 1991) emphasized problem solving as the main focus of school mathematics. As a result, most curriculum materials developed in the context of mathematics instruction in the 1980s and 1990s were guided by this theme until it became unclear the role that problem solving should play in the larger context of school mathematics. Regarded as a postmodern condition created by modernism, the goals of mathematics instruction and the role of problem solving within these goals are questionable from a postmodernist perspective. The view that mathematics is a body of facts and procedures dealing with quantities, magnitudes, and forms, and the relationships among them, simply trivializes mathematical knowledge and polarizes the aesthetic, utilitarian, and other values. Schoenfeld (1992, p. 335) argues that “a curriculum based on mastering a corpus of mathematical facts and procedures is severely impoverished – in much the same way that an English curriculum would be considered impoverished if it focused largely, if not exclusively, on issues of grammar.”

3. Survey problems and Polya's method

George Polya devised a four-step method⁵ for mathematical problem solving that involved using ‘heuristics’ for the development of mathematical assertions. The method, when applied systematically to a survey problem, leads to a textual analysis of the problem through a process of plausible reasoning. Plausible reasoning leads to discovery of mathematical assertions embedded within survey/word problems. As an illustration of the method to survey problems, a set of assertions derived from the problem solution can prompt real understanding. The method requires a step-by-step approach; at each step a statement is formulated and the learner is guided into representing the statement graphically. The approach may be regarded as bottom-up, backward chaining or expository but focus is on graphical representation of mathematical statements through guided discovery rather than learning about sets (see OLS Exhibit 2, Appendix 16). In contrast, textbooks favor an axiomatic approach to survey problems with emphasis on application of set-theoretic notation (using union, intersection, and disjoint sets)

⁵ (i) Understanding the problem; (ii) Devise a plan; (iii) Carry out the plan; and (iv) Look back.

rather engaging children to reflect and disclose their own ideas about graphical representations of mathematical assertions.

4. Concept formation

Concept formation is a core component of elementary mathematics education that provides children the elements of basic concepts that determine their future mathematical thinking. In the process of teaching basic concepts, teachers tend to rely on definitions of key terms (e.g. the degree) and demonstrations rather than getting them involved in transactional processes that lead to the formation of mathematical concepts. Such approaches have not led many children to recognize the physical distance conveyed by a meter, nor do they easily grasp the notion of degrees, rational numbers, or powers (exponentiation). The problem with learning basic concepts in elementary mathematics is that concepts are organized in some sort of structure in long-term memory (Langford, 1987), so that while textbooks emphasize subject matter knowledge, it is seen that craft knowledge, which guides concept formation, is virtually non-existent. The OLS Exhibit 2 (Appendix 15) shows a procedure for introducing the concept of degree and angle measure that facilitates understanding and conceptual formation. The method, used by Babylonians some two thousand years ago, appears to be valid even today, yet this powerful activity-based approach to concept formation has seemingly not been adequately researched for its conceptual and cognitive values and practical approach to concept formation. Standard V textbook (p. 146) introduces the concept of angle measure through activities involving comparing different angle drawings with tracing paper (being used as a yardstick), without addressing the notion of degrees in the first place.

As far back as 1935, Brownell (cited in Romberg & Carpenter, 1986) argued that effective instruction in mathematics needed to be grounded in an understanding of basic concepts of mathematics. While the theories of Ausubel (1965) and Bruner (1866) focused explicitly on the structure of content to be learned and could be applied more directly to the curriculum, Piaget's logical operations have been related to understanding basic mathematical concepts and developing skills, based on the development of the foundations of basic number, measurement, and geometric concepts within a concrete operational framework. Even the principles of Gestalt psychology are consistent with the idea that instruction should focus on understanding fundamental concepts. While understanding is being promoted in lower primary textbooks (Standard 1 – III) through transactional processes that impose activity-based learning with real objects (see Figure 9), much of upper primary curriculum focuses on the unitary approach of

problem solving rather than combining the technique with discovery learning to emphasize development of fundamental and essential concepts in elementary mathematics. Children's cognitive processes are developed through progressive mathematization, guided discovery and bridging their conceptualization of mathematics with the real world (see Figure 9). These approaches form the tenets of Realistic Mathematics Education as advocated by Freudenthal (cited in Heuvel-Panhuizen, 2003, section 7.5).

A third dimension of mathematics instruction that leads to development of mathematical concepts is critical thinking. According to Wheeler and Wheeler (1995) critical thinking in mathematics involves processes of problem-solving, communicating mathematics, and reasoning (inductive and deductive). A well-designed mathematics course should integrate skills of inductive reasoning and problem solving, offer opportunities to learn and practice basic concepts of logic, and use these concepts in mathematical reasoning. While mathematical reasoning involves an interplay between intuitive, information exploration and formal systematic proof (National Council of Teachers of Mathematics, 1991), the development of abilities in deductive and inductive reasoning form the core of critical thinking in mathematics education. The reference to problem solving as the focus of school mathematics does not refer to the mathematical knowledge necessary to compute the answer to a specific problem. Rather, it refers to the set of tools and strategies commonly used to address open-ended problems. However, these tools and strategies are most easily described in the context of mathematics, though they also have wide applications in areas that are not mathematical in nature (Wheeler & Wheeler, 1995).

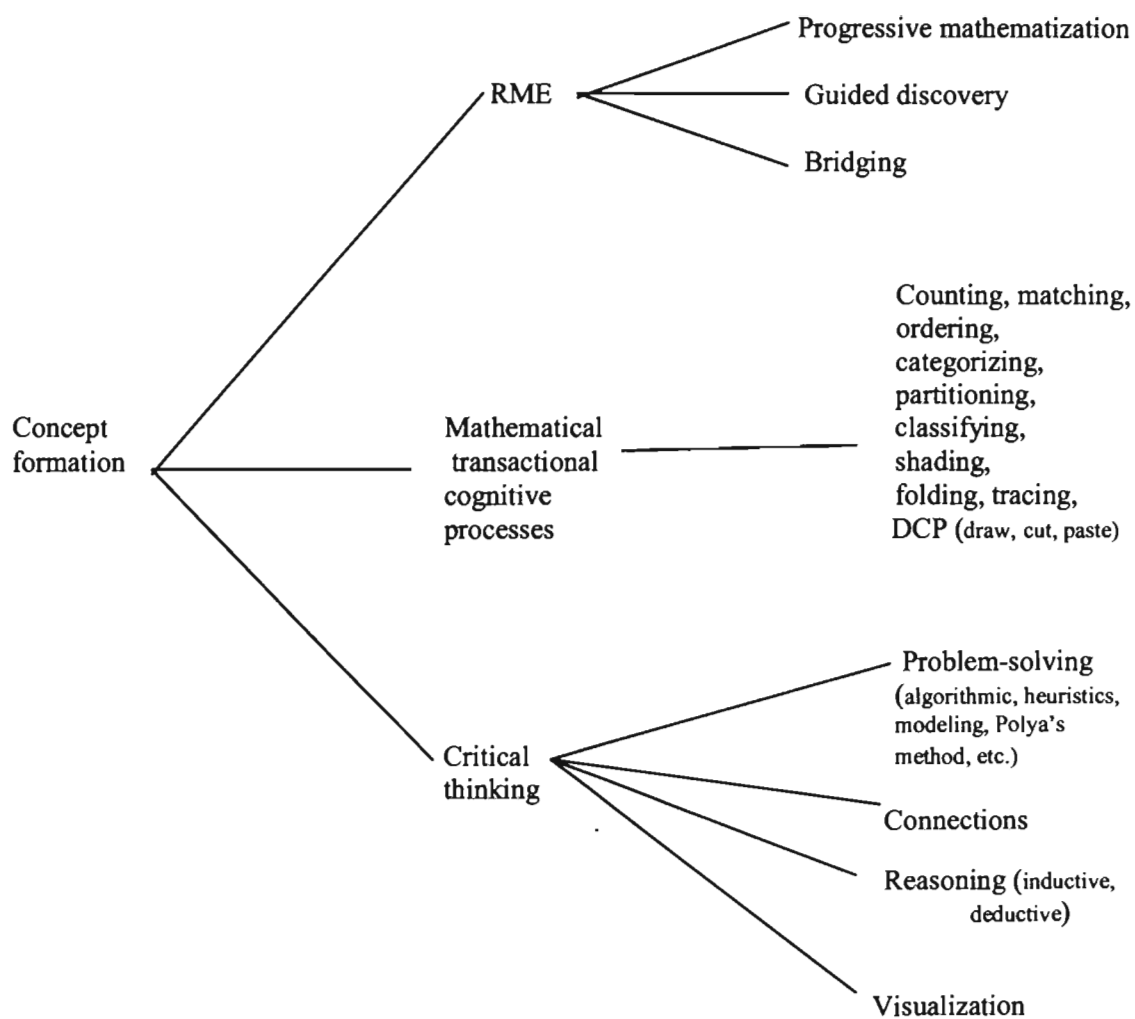


Figure 9. The concept formation framework

5. Geometry

According to Clements and Battista (1992), the primary cause of elementary school children poor performance in geometry has been attributed to the curriculum, both in what topics are treated and how they are treated. The major focus of the Standard IV textbook is on recognizing and drawing lines (vertical, horizontal, parallel, diagonal), parallelograms, kites, and lines of symmetry. Standard V textbook emphasizes on comparing the size of angles, identifying right angles and different types of triangles (isosceles, equilateral, scalene, etc.), and revisiting lines of symmetry. These unrelated concepts are further pursued in the Standard VI textbook where the main focus is on recognizing and naming geometrical shapes, writing the proper symbolism for simple geometric concepts, and developing skills with measurement and construction tools such as a compass and protractor.

These curricula represent an impoverished geometry curriculum comprising a hodgepodge of incongruous concepts with no systematic progression to development of higher levels of thought - "levels requisite for sophisticated concept development and substantive geometric problem solving" (Clements & Battista, 1992, p. 422). Usiskin (1987, quoted in Clements & Battista, 1992, p. 422) argues that "there is no geometry curriculum at the elementary school level." This view has been predicated on the fact that geometry as a mathematical topic is given brief cursory coverage in elementary textbooks and taught merely for 'exposure' rather than developing geometric thinking and spatial reasoning. To an uncommitted observer, elementary textbooks 'expose' geometry as a set of unrelated concepts apt for rote memorization. Instead of elaborating on the development of properties, class inclusions, relationships, and implications (Mayberry, 1983) for aesthetic appreciation, most of the geometry in elementary textbooks lead to misconceptions rather than develop logical thinking abilities and spatial intuition about the real world (Suydam, 1985).

5. Ratio, proportion, and percentage - the model approach

The treatment of these topics in the Standard VI textbooks shows a disproportionate view of ordering of logical sequence of mathematical presentation. It forms part of mathematical knowledge that concepts of ratio and proportion are closely related to the rational number (Wheeler & Wheeler, 1995) and logically precede the concept of percentage. However, it is found that the reverse is unwittingly prioritized in the section dealing with these topics in the Standard VI textbook (p. 213 – 246): the anomaly is that percentages are introduced prior to ratio

and proportion. While this lopsided approach may be partly responsible for mathematics being experienced as a difficult subject, the anomaly also explains the perceptual dissonance often associated with mathematical presentation.

Kieran (1988, cited in Behr *et al.*, 1992) presents a network of personal rational number knowledge consisting of six levels of knowledge. The first level contains constructs that are very local (ethnomathematics) and close to the fact level, while the next level comprises constructs of partitioning, equivalencing, and forming dividable units. The third level comprises constructs of measure, quotient, ratio number, and operator. These four levels have received adequate pedagogical treatment in Standard III (p. 30 – 38) and Standard IV (p. 51- 59) textbooks to foster concept formation of ratio and rational numbers.

The treatment of the more formal constructs of fraction and rational number equivalence in the fourth level (Standard V and VI textbooks) are based on heuristics that encourages guessing and processing for solution through trial and error approach. The basic knowledge of ratio, proportion and percentage that one acquires through application in a particular environment, and that relate to one's every experience (also called ethnomathematics), needs a far more pedagogical approach than heuristics. It is proposed that modeling as a strategy for problem solving, and that involves using the real number line, tabulating and 'concept mapping', is for more practical than heuristics which children find rather difficult to conceptualize. The focus on problem solving without clear guidelines on how to process the given information and the absence of a sensible approach as good as mathematical modeling are the main shortcomings of the upper primary textbooks.

7. Thematic weight distribution in textbooks

Thematic weight distribution refers to the relative weights assigned to mathematical topics in terms of page coverage and length of treatment in textbooks. The amount of time spent on a topic influences children's interests in the subject, especially in understanding and internalizing its contents. It has been found that children do well and show interests in topics having relatively small thematic weights in terms of teaching time and depth of coverage. Table 17 shows the distribution of weights in terms of page coverage and relative weights for the five topics comprising Standard V mathematics textbook (1998 edition).

<u>Topics</u>	<u>Pages</u>	<u>Relative weight</u>
Numbers	44	0.48
Sets	7	0.08
Measures	24	0.26
Geometry	14	0.15
Graph	3	0.03
Total	92	1.0

Table 17. Thematic weight distribution for mathematics topics in Standard V textbook.

The graph (Figure 6) shows an overemphasis on numbers and measures compared to geometry, while sets appear to be prioritized over graphs. Additionally, the extended emphasis on numbers and measures reflect an unbalanced learning curve inconsistent with Piaget’s developmental theories and Vygotsky’s concept of scaffolding.

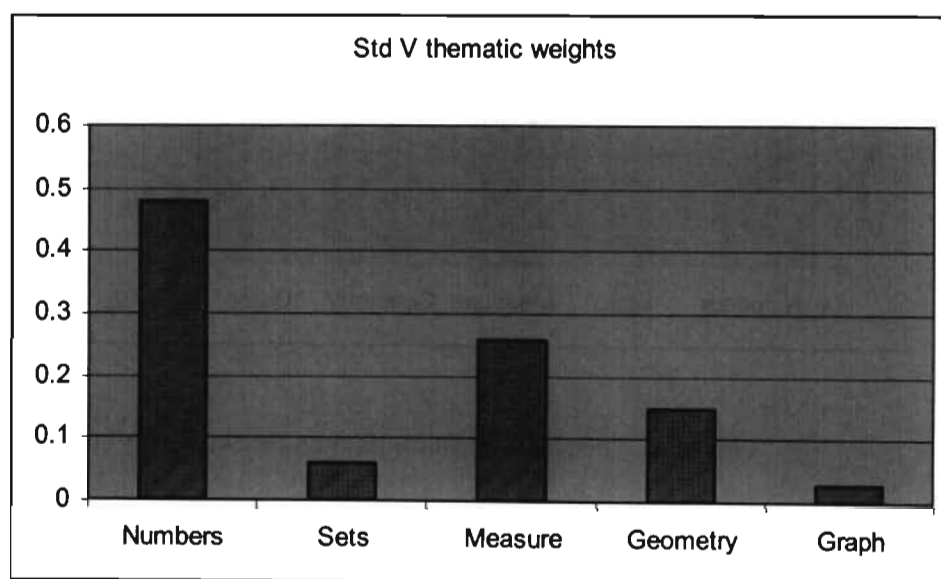


Figure 6. Thematic weight distribution for Standard V textbook.

For the purpose of comparison, a thematic weight distribution for topics in Standard VI mathematics textbook (1998 Edition) is shown in Table 5.

Topics	Pages	Relative weights
Numbers	89	0.44
Sets	8	0.04
Measure	67	0.33
Geometry	18	0.09
Graph	20	0.10
Total	202	1.0

Table 14. Thematic weight distribution for mathematics topics in Standard VI textbook.

The accompanying graph in Figure 7 reveals that topics in geometry and graphs have the same level of treatment while sets seem to receive a lower profile.

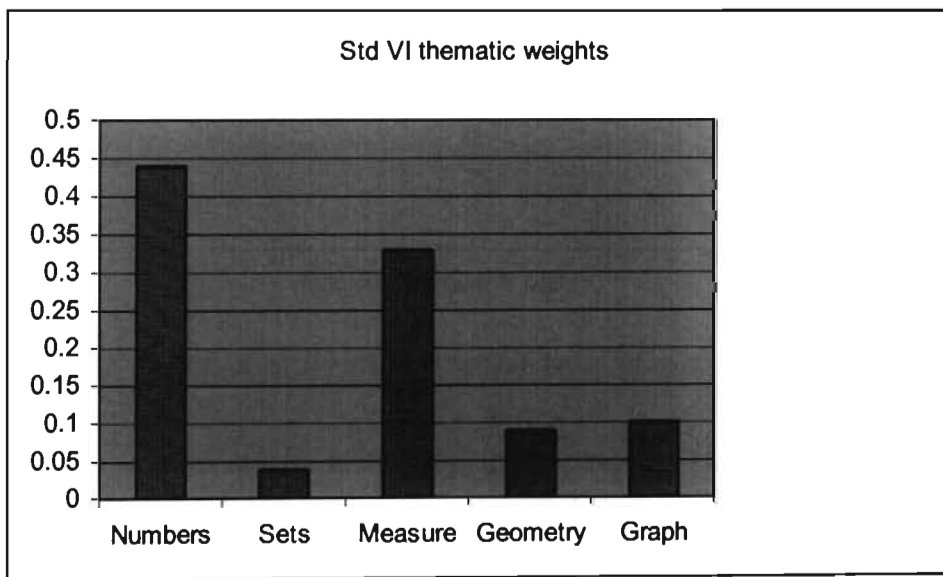


Figure 7. Thematic weight distribution for Standard VI textbook

Figure 8 provides a comparison of thematic weights for both Standard V and VI. The figure shows the topics in measures and graphs receiving more consideration in Standard VI classes, while numbers, geometry and sets being given relatively lower importance.

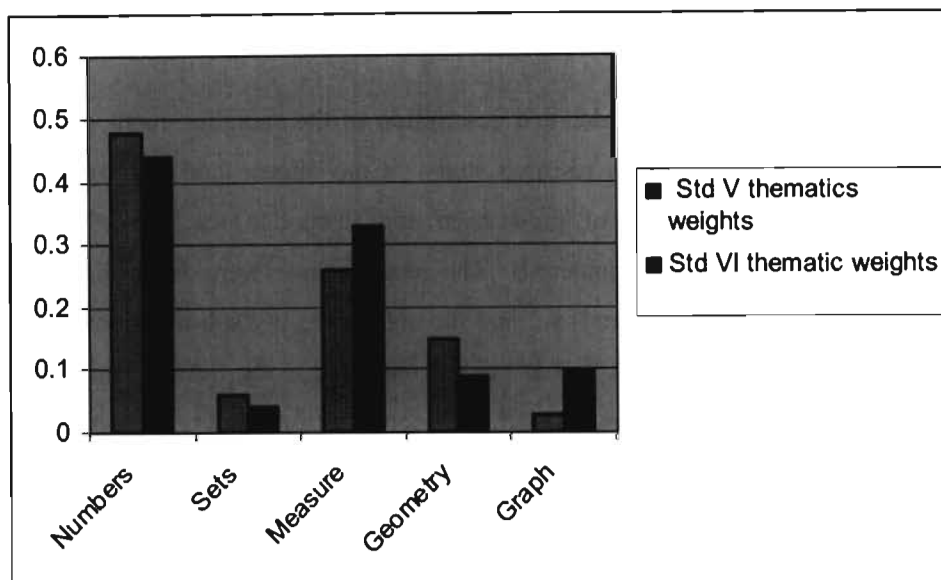


Figure 8. Thematic weight distribution for Standard V and Standard VI textbooks

Analysis of texts in terms of thematic weight distribution can provide important insights into the planning of texts in curriculum development activities where the focus in matching curriculum objectives to learning outcomes tend to override important considerations in design. The goals of providing consistent or uniform thematic weight distribution in mathematics textbooks need to be further researched to study its influence on teaching and learning. However, it remains to be shown that adherence to a consistent weight distribution in curriculum restructuring would address problems of modality and dissonance characteristics of most textbooks in elementary mathematics where thematic weight distribution is not a major consideration.

4.10 Distributed learning for teacher development

The expression ‘distributed learning system’ is regarded in this study as an umbrella concept that encompasses a broad range of instructional systems involving man, machine, and electronic communication resources. The distributed learning systems may be directed towards sharing instructional content over Internet or across various intranets, but may lack the interactivity of ‘interacting learning systems.’ Being technology-driven, its strength lies in its outreach capability irrespective of time and space. Though interactivity is regarded as an essential component in all forms of learning, sharing content and information in distributed learning enhances learning among adults.

4.11 Summary

This chapter has provided a detailed description of the sampling methods and the instruments used to collect data for this research study. Convenience and purposive sampling methods provided the two samples of pre-service and in-service teachers who were administered Questionnaire A and Questionnaire B. The questionnaires were designed to elicit answers to the key research questions A.1 and A.2 and the accompanying sub-questions. The analysis of the data from Questionnaires A and B were conducted using SPSS (Statistical Package for the Social Scientist) and Microsoft Excel. The conversational interview data and the focus group interview data that resulted from the cohort analysis were analyzed using the QSR⁶ NVIVO software. For the content analysis, Microsoft Excel and SPSS were employed.

⁶ QSR = Qualitative Solutions and Research International.

Chapter 5

The findings, the report, and discussions

5.1 Introduction

This chapter examines the findings from the analysis of the research data of the previous chapter. The study investigated the issue of developing a model for the professional development of primary mathematics teachers in Mauritius and, in the process, highlighted a range of human and educational issues that have beset the system of education. The study approached the main issue using a multi-faceted approach to the effect that the locus of the investigation unraveled a multiplicity of collateral issues and theoretical concerns related to teacher development and the quality of education. Among these are developmental issues relating to teacher preparation programs, issues of continuing professional development in an age of information and communications technology, and the need for curriculum restructuring in the ongoing reform process. The analyses of the previous chapter focused onto these changing educational needs within a global perspective, in the context of a society poised to enter a new world order dominated by information and communications technology (ICT).

The findings in this report are based on the analyses of survey instruments (questionnaires and interviews), and the evidence gleaned through ethnographic investigations in the course of field work. The report embodies a synthesis of empirical findings and ideation in terms of continuing professional development (CPD) practice, reform in teacher education, and curriculum change, as these are expected to answer the research questions posed in Chapter 1. It needs to be mentioned that the study grew out of the researcher's concern for failing standards resulting in low performance in schools, with its toll on drop-outs and accompanying untold societal problems. A more in-depth investigation of causal and explanatory factors would require broadening the scope of this study to include a wider range of issues raised in the first chapter, for example, private tuition, dropt-outs, teachers' burn-out and fatigue.

With the changing nature of learners' demands, economic pressures, technological developments, and the critical increase in the mass of learning population in this century, definitions of what constitutes education and training are changing. The heavy investment in emerging technologies is strengthening the belief in the importance of the link between

educational investment and economic growth and development. The massive investment in education through provision of new technological infrastructure has opened up new vistas for rethinking teacher education and curriculum. The use of distance learning technologies and e-learning are proving to be tools of the twenty-first century that will revolutionize the mode of delivery of education and training to an ever increasing mass of teachers.

The key findings that emerged out of the discussions and analyzes in the previous chapter are framed as educational indicators and performance standards¹ (see Figure 1 below). While educational indicators serve to indicate the inputs to an educational system with the goal to improve overall performance, performance standards monitor and evaluate its performance. In the latter perspective, teacher education (both pre-service and in-service), curriculum and assessment are regarded an important characteristics that impacts on classroom practice and students' performance.

5. 2 Answering the key research question RQ 1

The following section addresses the key question RQ 1 and sub-questions RQ 1.1 – RQ 1.4 raised in section 1.11. The are reproduced for ease of reference:

RQ 1. What model of professional development of teachers would bring about change in performance and overall improvement in schools in Mauritius?

Sub-questions

RQ 1.1. Is professional development of teachers linked to the quality of education and the reform of curriculum?

¹ In the literature, the terms educational indicator, quality indicator, outcome indicator, performance standard, and performance measure are used interchangeably. According to Madaus & Kellaghan (1992) 'there is a general agreement that indicators or standards are single or composite statistics that reveal something about the performance or health of an educational system. In particular, quality or performance indicators are regarded as the nation's barometer of education wellness.' However, in the international context, the term 'educational indicator' has been used to describe key aspects of evaluating an educational system, or a significant part of it, which might be useful for policymakers (Johnstone 1981, cited in Madaus & Kellaghan, 1992). Educational indicators refer to the inputs into an educational system (e.g., pupil-teacher ratio, access, equity, absenteeism) or to outcomes (e.g. student achievement, educational attainment). They may be used to monitor an educational system over time, to evaluate its performance, or to make international comparisons.

- RQ 1.2. Is the ‘subject teaching’ formula (of 1994) a viable alternative to resolve teachers’ pressures in terms of cognitive overload, classroom fatigue, and to bring about change in performance, through subject specialization, in schools
- RQ 1.3. How important is Information and Communications Technology (ICT) and distance learning in the professional development of teachers within the process of an educational reform that has a vision to lead a nation into the information age?

The deliberations are based on the analysis of the data in the previous section.

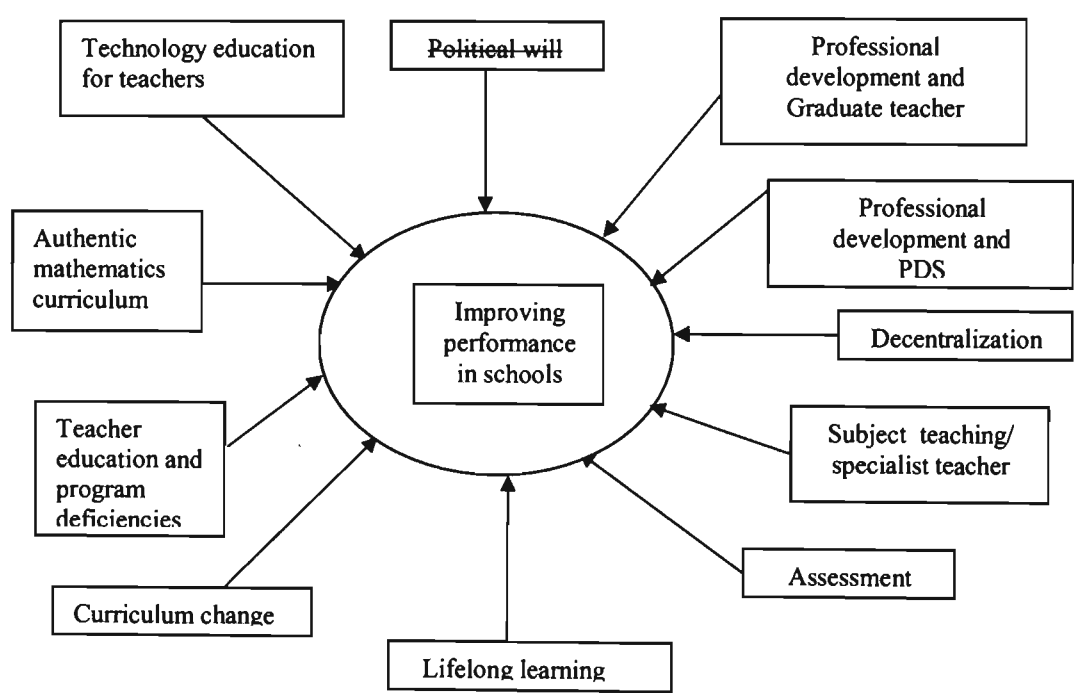


Figure 1. Educational indicators for improving school performance

1. Model of professional development

The models of professional development reviewed and discussed in chapter 2 (section A) show how important the school has become as a focus for professional development. However, the analysis of Questionnaires B show that 80 % teachers surveyed would prefer to attend their former training institution (MIE) to upgrade themselves professionally. They do not believe that

the key to improving school performance resides with teachers, school administrators or learning at their workplace (i.e. the school). The training model (see section 2.4.4) is cost-effective and promotes the support of school teachers in capacity building of their peers. Yet experienced and veteran teachers still believe that teacher development can be done only at the training institute, i.e. the MIE, although teachers and administrators have better knowledge of the school terrain and their own needs than educators and teacher trainers who are cut off from the realities school life.

The analysis of Questionnaire A revealed that 85 % of beginning teachers value the importance of initial training programs as beneficial to their work lives. However, teachers in the age-group 40-55 years believe that their initial preparation programs do not influence instruction in their classrooms. Thus, creating the professional development schools would help to build a link between schools and the training institution with the intent to foster development and growth of teachers.

Based on the empirical evidence in this study, no strategy could be recommended for the implementation of teacher development and growth unless professional development becomes integrated in school ethos with resultant change in conditions of employment of teachers. Teachers completing initial training should be hired as novice on contract basis following an extended probationary period of 3-5 years to enable engagement in directed tasks, similar to action research (often referred to as practitioner-based research), under the supervision of senior teachers or head teachers. If schools are meant to maintain the social order, then any reduction in school hours should be compensated with commitment of staff to undertake professional studies having direct bearing on enhancement of classroom practice. In brief, it is high time for professional development to be institutionalized within every single school system; it must not only flow in the school water system but be part of the school ethos (Grant, 1998).

As a first step in initiating professional development schools (PDS) in Mauritius, schools having professional development capabilities should be identified on the basis of their overall performance in key-stage examinations. Schools with success rates of 70-80% at CPE examinations would automatically qualify for PDS status, irrespective of their geographical location, whether located in a rural or urban area. While fewer schools would qualify for PDS status, a benchmark of 70-80% success rate could serve as criterion for schools to progressively increase their success rate to attain the PDS qualifying mark. While it is true that PDS would attract increased enrolment from areas outside designated 'catchment' areas, it would be wise to

post trainee teachers in PDS schools for teaching practice, as in the ‘immersion and reflection model’ (section 5.4.7). Low performing schools need to increase performance to attract trainee teachers for teaching practice. (Although no figures are available, a high proportion of student teachers prefer to be posted in high performing ‘star’ schools for teaching practice.)

Schools with PDS status should enter into a form of partnership (or link) with the host institution (the Mauritius Institute of Education) in a ‘joint venture’ to support trainees on teaching practice, to induct novice teachers into the profession, and to organize action research groups for continuing professional development (CPD). It is important at the initial stage of the project to create a School Improvement Committee (SIC) within each PDS and to select veteran (seasoned) teachers to serve as co-members on the committee. A comprehensive term of reference need to be worked out to provide guidance and direction in areas of curriculum development, mentoring of trainees (on teaching practice), organizing and conducting action research for continuing professional development. Teachers serving on school improvement committees (SIC) should learn new skills – teaming skills, interpersonal skills, and research practice skills - in developing communities of practice within the new learning environment. Such communities are built on principles of ‘co-participation’ and are focused on improving schools and teachers.

A point that came to the fore through the informal conversation interviews is the professionalism of veteran (seasoned) teachers and school administrators in terms of their knowledge for the overall development of the learner (in terms of knowledge, skills, attitude, affect, and values) and awareness of school problems and their willingness to reform education. Thus, PDS schools are predicated on the notion that teachers value their peers as trainers because teachers can learn as much from their peers as from expert trainers (see training model – section 2.4.4). This reinforces the view that schools have the potential to undertake continuing professional development (CPD) within the new learning environment induced by professional development schools.

2. Subject teaching/specialist teacher

The analysis of responses from experienced and veteran teachers show that there is general consensus for the need to revert back to 1994 subject teaching formula. The subject teaching formula entails teaching a selected range of subjects of the elementary curriculum with a view to specialization in the subject domains. According to the formula, teachers were streamed into science or arts curricular routes. The formula needs to be reviewed and restructured to meet the

new demands of the twenty-first century schools. However, extreme caution must be exercised when extrapolating from the recent past. Major aspects of the subject teaching formula must be reviewed, especially with regard to increasing specialization in subject domains and the need to eradicate private tuition. The goals of subject teaching must be geared towards reforming practice. In this respect, the underlying principles and processes of the formula must be reviewed in relation to whether reformed practice engendered by specialization in subject disciplines can result in 'braking' the system of private tuition. With the revised pay and salary conditions following the 1998 Pay Research Bureau (PRB) awards, working conditions of teachers have remained almost unchanged, except for a marginal extension of school hours. It is felt that teachers are now better prepared to embrace the subject teaching formula they rejected in 1998, after a few years of implementation. Subject teaching would inevitably lead to decrease in workload, fatigue, and would help attenuate the effects of burnout syndrome endemic in the system. Streaming to subjects specialization would as well decrease cognitive overloads and would provide teachers opportunities for more specialization in subject areas and thus reform classroom practice.

3. The role of ICT and distance education in professional development of teachers

Most colleges of education around the world are moving towards opening access to a wider clientele by offering online distance learning (ODL) courses. Distance modes of teaching and learning, combined with occasional face-to-face meetings between tutors and students have proved to be increasingly popular worldwide, especially in the areas of mathematics and mathematics education (Arnold *et al.*, 1996). It is argued that mathematics education is frequently seen as particularly suitable for the application of computerized teaching and learning (Morgan, 1994). The potential of computer technology in the flexible modes of course delivery process has been established, during the last three decades of this century, as a viable alternative to traditional distance learning methods. While many institutions transfer their traditional courses on-line to be delivered in distance mode, courses designed for on-line distance learning (ODL) must move educators away from behaviorism, towards constructivism and reflective learning. The main tasks of mathematical programs to be offered in distance mode are to enable teachers to acquire competencies and skills in transferring basic concepts.

It must be recognized that it is the form and structure of instructional materials presented through Web technology that determines the nature of the pedagogy in fostering adult education in

distributed learning environments. The characteristics of adult learning (see Appendix 4) also dictate the pedagogy of web platforms, not as a technological innovation to exploit the capabilities of technology but rather to meet an instructional need and a learning goal. A pertinent *démarche* in web-based learning would entail matching the instructional materials to the needs of the clientele to ensure relevancy of tasks. While the nature of web platform facilitates behaviorist approaches to teaching-testing/evaluation process, the model is constitutive of engaging adult learners as self-directed, self-regulated, goal- and relevancy -oriented, and practical - attributes being characteristics of adult learning theory (Knowles, 1980).

All too often instructional designers, in focusing on individual learners encountering the machine interface, seem to overlook other aspects of education – namely, the cultural and historical approaches (Russell, 2004) Although human computer interaction favors behaviorist stimuli-response learning approaches in the delivery of instruction in distributed learning environments, it is not possible to ascertain whether human learning is taking place while the individual learner encounters the computer interface. Russell (2004, p.309) argues that

“(s)ome people do not learn at all but turn away from the screen, lacking motivation. Some interpret the ‘materials’ in ways we may not expect (and may not like). People learn (and forget) to different degrees and in different ways, or put that learning to unexpected uses which thwart our objects as teachers/designers.”

For an individual responding to stimuli on the screen and internalizing ‘materials’ (text and visuals) through repetition, the learner’s development system experiences problems of human learning implicit in distributed learning environments. Amory (2004, p. 6) argues that “the more sense we use when learning, the better our retention and understanding.” The author further argues that the use of multi-modal processing (engaging in concurrent perceptual modalities) does seem effective provided it is used correctly and is gaining support within advocates of multimedia instructional designers.

On the issue of reflection and reflective practice as a component of learning, Wild and Quinn (1998) propose that it is currently not feasible to design technology applications to facilitate reflection directly, arguing a case for the development of intelligent tutoring systems (ITS). However, according to Hedberg (quoted in Wild & Quinn, 1998, p. 74) technologies can mediate and encourage reflection in several ways, “such as providing a communication link between

learners, providing tools for knowledge and outcome representation during activities, or simply displaying a record of the learner's activities." In distributed learning, reflection can be regarded as an innate quality of learners that is provoked by the nature of the instructional materials and between learners when abstracting from one's own experience. It comes as an experience through a process of reconciliation between experiential learning and academic learning. Learning without reflection may be equated to rote learning, a process that diffuses with maturation, especially among adults.

5.2.1 Answering the research question RQ 2

This section focuses on answering the key research question RQ 2 and the related sub-questions RQ 2.1 – RQ 2.3. These are produced for ease of reference:

RQ 2. How does a two-year teacher training program suffice to prepare teachers for a teaching career that spans 30-40 years?

Sub-questions

RQ 2.1 In what ways are failing standards in schools linked to the ITE program of the MIE?

RQ 2.2 To what extent is the quality of education received by children dependent on the quality of training received by teachers?

RQ 2.3 Does the present form of the ITE preparation program prepare future teachers to be reflective practitioners, use inquiry-based and constructivist approaches in teaching?

1. Teacher preparation program deficiencies and quality of education

The analysis of the responses to both questionnaires points out to the problems associated with the two-year preparation program provided by the MIE. The deficiencies and lacunae of the preparation program may be attributable to the low performance in schools and the quality of education dispensed in Mauritian schools. The analysis reveals that the most often critiques of such programs include: (i) design of teacher education program, (ii) inadequate preparation time, (iii) fragmentation, (iv) course overloading, (v) curriculum cloning, and (vi) teachers' attitude to the profession.

(i) Designing teacher education programs – the missing link

It has been seen that when it comes to designing programs for teacher training, faculties work in isolation from the schools and from the teachers for whom the program is designed. Admittedly, teachers and school administrators have better knowledge of the school terrain and the needs of teachers working in those schools than teacher educators who are virtually cut off from schools and the realities of school life. A recognition of this missing link between training institutions and schools would undoubtedly bring together many, if not most, stakeholders to contribute to the enrichment of preparation programs in an effort to meet the real needs of teachers and school reforms. A further condition is the realization of the extent to which teacher preparation programs influence instruction in schools. Though teachers' attitude to this issue is mixed, most beginning teachers (85 %) value the importance of initial teacher training programs as beneficial to their work life.

The analysis further shows that most teachers develop a repertoire of stereotyped instructional strategies that do not cater for all abilities. These practices serve as anecdotal evidence to condone the inherent deficiencies of preparation programs in many aspects of content and pedagogy on the basis that not all programs are inherently complete in the epistemic demands of teaching. The shortcoming may be partly attributed to the missing link, at the design stage, between training institutions and schools, between faculties and major participating stakeholders (e.g. curriculum developers), as each tends to function in isolation from one another. A viable way to explicate this phenomenon is that most programs, far from being complete, make deliberate provisions for a non-quantifiable amount of leeway to accommodate activities for future professional development activities or to encourage teachers conduct their own independent, practitioner-based inquiry (e.g. action research) in order to address future classroom needs. No teacher preparation program makes provision for all teacher needs. In an important sense, training programs are designed to be indicative of behaviors beginning teachers need to know about, and be aware of, in their workplace environment, notwithstanding that nothing is prescriptive in content or method.

(ii) Preparation time

The analysis of teachers' responses further show that no two-year teacher education program is adequate preparation for a demanding career of an elementary school teacher. In the Mauritian context, the two-year preparation program, shared between two semesters (30 weeks) of face-to-

face sessions and two semesters of teaching practice in primary schools (under the supervision of a mentor), is inadequate in terms of learning subject matter, child development, educational theory, curriculum studies, assessment, and effective teaching strategies. At present, there is some controversy about the adequacy and worth of a two-year initial preparation program. If the two-year program is designed with the intent to induct the trainee into teaching, will this initial preparation be adequate to meet the basic needs of schools in terms of promoting effective teaching-learning process? Darling-Hammond (1999) considers that even a four-year preparation for an undergraduate degree has been found to be well below the mark to respond to the needs of the profession and the school. Oja (1992) reports that a number of recent studies have found that typically five-year programs better prepare teachers (who are more like to stay in teaching) than their peers prepared in traditional four-year programs. The analysis reveals that teachers entering the teaching profession after completing the two-year pre-service training program are equipped basically with survival strategies to cope with on-the-job demands, to fill a vacant job at school. The effects of a limited preparation time are inclined to produce coping rather than capable teachers, a development that is indicative of the shortcomings in teacher preparation programs.

(iii) Fragmentation

Analysis of the responses shows that 85 % of the teachers surveyed, pre-service and in-service, value the relevance of pre-service and in-service courses, but have been unable to relate the acquired concepts to the teaching and learning of subject matter. In general, training programs tend to indoctrinate trainees into believing that programs help them acquire the basic competencies for teaching and that the school-based practice is instrumental in developing the requisite (healthy) attitude towards children and familiarity with school environment. To demonstrate this point, the study of thinking skills or the process-product approach to problem solving in elementary mathematics remains well nigh vain theoretical concepts that teachers find difficult to link to practice. This theory-practice disjuncture reflects the nature of teacher education program with their mostly disparate and disconnected elements of learning, delivered by different faculties operating in isolation from each other. Would-be teachers are left to their own devices in piecing together the fragmented chunks from different faculties, in an effort to make out a holistic picture of the disconnected learning elements, without ever discerning the missing ingredients necessary to harmonize the different parts into a consistent and logical whole.

(iv) Course overloading

The conversational interviews and focus group interview data reveal that various factors have affected performance and the quality of education in schools. Apart from the limitations generated by the structure and delivery of initial teacher education (ITE) and the shortcomings cited above, problems are also attributed to teachers' increased fatigue owing to excessive workload. This view confirms Huberman's (1993) research on causes of teachers' fatigue. The ethnographic investigations also reveal that the problem has been found to be further compounded with new family obligations (marriage, the birth of a child, constructing one's own roof, etc.) which are not unusual to coincide with the debut of a professional career. (Young teaching couples prefer marriage to cohabitation when settling down with a professional career. In Mauritius, cohabitation is hardly practiced and is viewed as asocial and often immoral by traditional orthodox families.) For beginning teachers, the beginning phase of a career is a difficult period that weighs heavily on professional lives.

Huberman (1993) relates excessive workload to increased fatigue. Fatigue has also been the result of increasing demands in terms of performance standards and on-the-job demands that are often interpreted by teachers as exacting and ever-expanding. (Beginning teachers often feel to be psychologically put off by the range of subjects they are required to teach as a general purpose teacher and, depending on the school, they feel that the standards set are too high.) There is also the need for increased throughput from the extent of knowledge specialization that, for the trainee teacher, spans no less than ten modules, from English, French, Mathematics to Living Values and Drama (see Appendix 1). Most teachers teach six to seven subjects for which they had not received in-depth training. These factors account in part for teachers' lack of motivation to undertake professional development activities. Other reasons are attributed to work schedules that have been found to be too tight to accommodate new or other activities. Overcrowding in classes is often a common feature that bears on the teachers' morale and throughput. In Mauritian primary schools, teachers benefit from a daily one-hour pause that they are required to spend within school premises. During the pause, the next lesson is being prepared or rehearsed.

It cannot be denied that some schools have their own lot of teachers suffering from burn-out, classroom fatigue and who are spared from a full teaching load (usually replacing colleagues on leave) and yet are on the payroll. Brouwers and Tomic (2000, p. 2) describe burn-out as "a psychological syndrome of emotional exhaustion, depersonalization, and reduced personal accomplishment that can occur among individuals who work with other people in some capacity."

However, there is empirical evidence that burn-out arises from a combination of factors; Huberman (1993) has documented that experiences both in private life and in the classroom contribute to the phenomenon. An unstable and chequered private life – personal and family events – can verily destabilize teachers in their professional lives. Friedman (1995) reveals from interactive research conducted as part of classroom observations that student disruptive behavior has a positive effect on teacher burnout. However, student discipline problems may trigger the onset of burn-out, but interviews with school administrators (deputy head teachers) have revealed that a combined syndrome of fatigue and burnout is discernible especially among some older teachers. The main causes are due to basically three factors, namely (i) frustration for not being promoted, (ii) daily exposure to routinized tasks, especially private tuition after school hours, and (iii) skepticism towards school and school life.

2. Learning needs of teachers of the future

Teacher preparation programs must consider technology education as a core component in its effort to promote the concept of technology use schools. The purpose a core curriculum in technology education is to prepare the present generation of teachers to cater for the needs of future generation of learners. The core curriculum is intended to engage teachers to explore basic concepts and ideas through the lens of technology rather than applying technology to particular problems, without discarding teaching aids and other artifacts that have traditionally been used in concept formation of children. Instructional goals of teacher preparation in mathematics education must have a technology focus for teachers to acquire a technology disposition rather than using technology for its own sake. This change in teacher learning brings a shift in the teacher's perception of mathematics education, not as a collection of bits of information and procedures but as the active construction of knowledge and competence.

3. Time for and trust in teacher development

The focus group interviews reveal that time as a factor is crucial in facilitating teachers' learning in the work place. The need for extra or additional time dispensation for teacher development seems to converge towards a technical rational formula of engaging teachers in additional activities within an already tight schedule at the risk of extending the long-established, traditional 5-day, 6-hour school day. "It is essential to provide teachers with adequate release time for planning, for collaborative work with colleagues, for access to consultants, for visiting other

classes, and for evaluating innovations and new practices” (Grant, 1998, p. 6). Approaches to teacher development based on employing a monolithic solution that relies on time appropriation tends to further problematize the issue by overlooking a long-standing moot point – the school schedules. These have variously been criticized as being overloaded, both in terms of curriculum and teachers’ work and cognitive overloads. The process of impounding, even marginally, on teachers’ already tight schedules further complicates teachers’ lifeworlds, already subjected to classroom fatigue, burn-out, and overload problems. When teachers learn with new technology, substantial investments of time are required to master them and to develop meaningful contexts for their use. Grant (1998) argues that because of the constantly changing nature of hardware and software, teachers need time on an ongoing basis in order to keep up with upgrades.

Teachers need education, not training (Stenhouse, 1975). Ovens (1999) argues that there exists a coherence of values between educators and learners, between the processes of teaching and learning that is based on one of the most fundamental of values, and that is *trust*. Trust refers to a faith in a learner’s ability to develop control and responsibility for their lives, actions and learning. Regarded as a *sine qua non* of education, the educator has to trust the autonomy of the learner to use their education wisely in determining how to think and act and does not expect knowledge to reap the reward of conformity in learners’ thinking.

4. Teachers as reflective practitioners, using inquiry-based and constructivist approaches

Analysis of the responses to the questionnaires reveal discrepancies in teachers’ knowledge about student evaluation, diagnosis of learning difficulties, classroom management, planning constructivist and creative activities for children, skills in communication, curriculum planning and instruction. The analysis further shows that the majority of teachers rely on only prescribed textbooks for classroom instruction. This dependency on textbook for instructions reflect the philosophy of preparation programs that hone on content (subject matter knowledge) rather than developing teachers to become reflective practitioners and promote the use of inquiry based learning and developing constructivist approaches to teaching.

The concept of the reflective practitioner (Schön, 1986) influences teacher education at all levels of teacher preparation and development. It begins with the design and development of preparation programs to its implementation at pre-service, in-service, and continuing professional

development levels. Schön's version of reflective practice (reflection-on-action and reflection-in-action) encourages teachers to be action researchers and to develop more self-directedness – that is, self-learning from experiences in natural settings. Student teachers are encouraged to discuss reports of their field experiences (e.g. teaching practice) with mentors and peers in a collaborative effort to enrich and refine students' personal reflection on their work (Ferraro, 2000). This model of teacher development also supports portfolio/project/problem-based learning (pbl) which has become a favorite tool in pre-service and in-service teacher education and continuing professional development. Pbl has a reflective component in that it allows beginning teachers to document their teaching practices, examine the lessons that worked well and why, what competencies they have learned and what teaching they can relate to their practice. Reflective portfolio work touches on the meta-cognitive and eclectic nature of learning characteristic of adult learners

Schön's model of developing the reflective practitioner also encourages the teacher educator to be a researcher and a role model. It also encourages students to put theories they have learnt into practice in their classrooms. Ojanen (1996, cited in Ferraro, 2000) extends the role of teacher educators in pre-service education to one of coach in reflective practice, while Uzat (1998, cited in Ferraro, 2000) presents coaching as a realistic and systematic approach to ongoing teacher improvement through focused reflection on teaching methods.

The concept of the reflective practitioner is embedded within the notion of 'lifelong learning.' The idea first appeared in a 1973 UNESCO report (referred to as the 'Faure Report'). Since then the term has been closely associated with the concept of 'the learning society', or more broadly with the 'knowledge economy.' The Faure Report urges 'lifelong learning' to be understood as "a master concept for educational policies in the years to come for both developed and developing countries" (Faure *et al.*, 1972, p. 2). In a broader sense, lifelong learning advocates the need to learn throughout life (Friesen & Anderson, 2004). The concept refers to the activities people perform throughout their life to improve their knowledge, skills and competence in a particular field.

The notion of life-long learning is a revival of the Ancient Greek idea that education is, or should be, a life-long process. Life-long learning offers itself as an educative rational aiming at making practitioners take responsibility for their own learning. The concept lacks "any shared understanding of its usage at the global level, and has often been characterized as an 'extraordinarily elastic term'" (Smith 2000, quoted Friesen & Anderson, p. 681). It is neither indicative

of what is to be done, nor prescriptive of how it should be done to be a life-long learner. In the present context, the only identifiable characteristic of the term carries an esotericism implicit to the practitioner who decides on how to take responsibility for her/his own learning. However, in a broader sense, other characteristics of the term have been labeled as the 'eclecticism' of lifelong learning and related to a wide range of learning: from learning that is planned, 'intentional' and curricular, to learning that is incidental and incorporated into real-time jobs aides, communities of practice, and leisure activities (Smith 2000). In the Mauritian context, lifelong learning must be regarded as the guiding principle for the provision of professional development to practicing teachers and the development of communities of practice.

5. Cognitive apprenticeship, action research and 'community of practice'

The analysis reveals that teacher education, as presently organized around a pre-service and in-service training paradigm, prioritizes face-to-face sessions to 'inoculate' teachers with pre-determined set of development activities that do not reflect their immediate needs. This approach has not produced the desired results. Teacher education and development must go beyond this one-shot injection of information. It must be seen as a continuing process that builds upon and supports the learning of teachers, via informal and flexible means as well as through more formal professional relationship.

Teachers' concern for their development can be categorized under three major influences: craft, authority, and reflective rationality. Within the category of craft influences, teachers' main concern is how changes in their pedagogical practices can bring about changes in their students' learning outcomes. In other words, teachers' development rests on the various influences of their practice and their understanding of their practice, both as a student teacher and, subsequently, as a practicing teacher. Development of craft knowledge involves, in particular, adoption of procedures and techniques in a situated learning context through a cognitive apprenticeship kind of relationship with other people. Cognitive apprenticeship is developed from situated learning. It attempts to create a situation in which the learner is brought into a domain as an apprentice and learns from those in the community with more knowledge. This form of learning uses authentic practices to make the experience as close to reality as possible. The method involves being an apprentice teacher within a 'community of practice.' The experienced teacher is an authority who possesses expertise and to whom the apprentice teacher is accountable for her/his practice (Ovens, 1999). Teacher development occurring within a developmental framework of a

community of professional practitioners tends to be organized and directed by people in authority, and with whom the teacher is most likely to have a more distant relationship, including that of accountability. This development could be called in-service training.

A reflective rational rather than a technical rational formula would encourage teachers to engage in inquiry-oriented development of their teaching and of themselves as professional persons. Learning about improving one's own practice by drawing on evidence about it, by considering others' ideas about it, and by exploring it with people with whom one sets up a professional relationship is reflective practice. 'A person whose development is achieved mainly in this reflectively rationalist way can be thought of as acting as an action researcher and their development could be called professional education' (Ovens, 1999). Inquiry and reflection form the cornerstone of teacher professional growth and development.

5.2.3 Answering key research question RQ 3

This section attempts to answer the key research question RQ 3 and the related sub-questions. These are quoted for ease of reference:

RQ 3. Is there a need to reform the primary mathematics curriculum to meet the needs of a new breed of learners in an environment strongly influenced by technology?

Sub-questions

RQ 3.1 What impact does curriculum reform in mathematics have on teacher development?

RQ 3.2 Can the present primary mathematics curriculum be used to prepare adults of the coming information age society?

RQ 3.3 What pedagogical orientations need to be used to re-structure primary mathematics curriculum?

1. Reform of the primary mathematics curriculum

The analysis of the informal conversational interview data (section 4.7.2) reveals the need for curriculum change at all levels of school and society. The overall perception of teachers is that the present school curriculum is outdated and hence cannot be used to prepare children to be the next generation of adults. The common perception is that the existing school curriculum has nourished private tuition, drop-outs and inequity in a system that seemingly catered learning

opportunities for all. There is wide consensus for transforming the school curriculum to meet the needs of the present generation of children, the 'cyberkids'.

Today's children are growing up in a world of computers and information technologies. Unlike the period prior to the television era, when the leisure of children were garnished with outdoor and indoor games with a variety of time-consuming hobbies (philately, gardening, kite-flying etc), the technological developments of the postmodern era have penetrated children's pastimes and, in its wake, bred a new generation of children - the cyberkids. Unlike children who grew up in the industrial age, cyberkids have developed a leisure culture of their own. They excel in computer, video, and arcade games; they 'wear' compact disks and are adepts of digital music. Few can articulate sophisticated mobile phones for the most complex (one-to-one, one-to-many) forms of electronic communication (bulk email, spamming, voice mail, sms, etc.), often attaining levels of complexities that break down barriers of age and precocity. They surf the Internet, use search engines to browse the most peculiar Website imaginable, and are exposed to 24-hour multi-channel cable tv broadcast. Some can at times even fake their identities into a teenager in search of an amorous freak over the Internet!

With these forms of engagement with technology, children have developed a natural propensity for things technological. Unlike the technofear that characterizes many teachers (the '17 per cent problem'²), the present generation of children forms the technophiles of tomorrow whose enthusiasm for technology has shown no sign of abating over the past decades. Even parents' anxieties over children's over-involvement with technology are at times allayed when they find children providing tips and cues for troubleshooting simple technical idiosyncrasies at home. Cyberkids excel in such tasks. The evidence is far more anecdotal at school where one too often experiences the 'technicist reversal phenomenon' – the student guiding the instructor in programming computerized controls of videocassette players or too often helping in debugging programs for the teacher, instead of the other way round.

² The '17 % problem' represents the technicians and visionaries who make up the 17 % of the (teaching) population who see a potential for technology and begin using it. The majority are not interested until they see some practical benefits (U.S. Department of Education, 1995)

2. The authentic mathematics curriculum - technology integration

The informal conversational interviews focused on the question: What is an authentic curriculum for elementary school mathematics? An authentic curriculum would represent a shift from the present absolutist perspective about mathematics to a social constructivist perspective where teaching and learning can be mediated by technology. One of changes in the traditional aims of education is to prepare workers for a new order spurred by the information age. As the economy adapts to the information age needs, workers must learn to interpret intelligent, computer-controlled processes. Most jobs will require analytical rather than mechanical skills, so most students need a new mathematics that prepares them for jobs of the information age. The extensive use of graphical, financial, and statistical data in daily newspapers and in public policy discussions would need a higher standard of quantitative literacy for the necessary duties of citizenship (Romberg, 1996). In that respect, school mathematics must be redesigned to reflect the needs of the new social order.

Over the past decades, significant changes in the nature of mathematics and the way it is taught have emerged as a result of reform in mathematics education in many developed countries. While social constructivist philosophy (Ernest, 1998) of mathematics is providing new directions in teaching and learning of mathematics, radical constructivist thinking (von Glasersfeld, 1995) is informing much current work in curriculum inquiry in mathematics and science education. It is providing the basis for reformulating theories of teaching and learning among instructional technologists and educational psychologists (see section 7.7.1, chapter 2). The growth in new areas of mathematics (mental arithmetic, estimation, LOGO, and so forth) and the variety of the contexts to which mathematics is applied have proliferated the use of computers in mathematics education. Conversely, the application of computers and calculators to mathematics have changed the way mathematics is done. A single fact that has significant effect on the mathematics curriculum is "that almost all of the mathematical techniques taught from kindergarten through the first 2 years of college" is now possible to execute on hand-held (graphics) calculators (Romberg, 1986, p. 772). Romberg argues that the changes brought about by computers and calculators are so profound as to require readjustment in the balance and approach to virtually every topic in school mathematics.

Elementary school mathematics has been in the limelight both among teachers and the public. While teachers realize the need for changes in mathematical curriculum, the public holds school

mathematics to be partly responsible for drop-outs³ in schools. These points make the arguments not only for a complete design of the content of the school mathematics curriculum but an urgency to retrain teachers in the pedagogy of mathematics to meet societal needs.

3. Technology integration in curriculum

The mathematical content of the present school curriculum is more than 100 years old. Yet efforts at integrating technology into the teaching of the subject have not produced the desired results. The traditional school mathematics is based on an absolutist philosophy, which regards mathematics as a fix and unchanging body of facts and procedures. This philosophy has also influenced the way mathematics is done – the emphasis has been to calculate answers to set problems with little regard to the ‘process’ of mathematics that leads to development of metacognitive awareness and creativity. The approach has engendered stereotyping with application of rehearsed techniques and time-tested routines in the solution of artificial word problems rather than solving realistic world problems.

Mathematics has been attributed to being one of the main causes for high drop-outs in Mauritian schools (Morrison, 1998). A quote from *Reshaping School Mathematics* (1992, p. 5) helps to reflect on the state of mathematics education:

“Many of those who drop out harbor life-long feelings of guilt or distaste for school mathematics. Some of those who become disenchanted with mathematics become teachers; others help decide educational and research policy for the nation. Very few adults ... have had the benefit of successful completion of a mathematics curriculum.”

There is a need for a radical shift towards a social constructivist perspective. Although the shift requires a fundamental restructuring of the entire educational environment, this report looks in particular at the elementary mathematics curriculum of schools. The current ‘transmission of knowledge’ model based on absolutist philosophies must give way to one based on social constructivist notions of mathematics. The transition will involve changes in content, modes of instruction, and methods of assessing student progress. Society considers the traditional school mathematics curriculum to have served its initial goals and purposes – without mentioning its

³ On June 8, 2004, while opening an e-learning workshop the Senior Chief Executive of the Mauritian Ministry of Education asserted that, according to UNESCO, ‘the pedagogy of the Mauritius Institute of Education’ has been largely responsible for the high drop-outs in our schools.

negative impact on children who leave schools because of mathematics. School mathematics must be redesigned to reflect a different social order spurred by information age, an order where creativity must have a central place. "A person cannot foresee exactly what knowledge he will need five or ten years from now to meet his life's problems. He can, however, develop the attitudes and abilities that will help him meet any future problem creatively and inventively" (Parnes, 1983).

In mathematics education, technology is becoming a tool to enhance learning and creativity. Although we still know little about what 'creativity' really is, we know how computers can stimulate greater creative behaviour in individuals, help them to release whatever creative potential they possess. Parnes (1983) argues that an individual's creative ability is frequently so repressed by his education and experience that he cannot even recognize his full potential. Once he can be helped to realize it, he may attain 'self-actualization'.

4. The structure of schools and classrooms

According to the analysis of responses of experienced teachers (Questionnaire B) and ethnographic observation of classroom organization, streaming is not practised officially, but the current structure of Mauritian schools is still organized around promoting streaming within the classrooms. Children of the poor, the disadvantaged, minority and 'excluded' groups are 'streamed' to occupy the rear seats of classrooms. Thus, the social divide phenomenon is still present at the micro level of classroom seating arrangements and characterizes a form of streaming that privileges children of affluent classes who are also the would-be clientele for private tuition. The classroom resembles a one-person show with a captive but often comatose audience. Classes are usually driven by "teacher-talk" and depend heavily on textbooks for the structure of instruction. The idea that there is a fixed world of knowledge contained in the textbooks and that the student must come to know still dominate most of the modes of instruction. Information is divided into parts and built into a whole concept. Teachers serve as pipelines and seek to transfer their thoughts and meanings to the passive students. There is little room for student-initiated questions, independent thought or interaction between students. The goal of the learner is to regurgitate the accepted explanation or methodology expostulated by the teachers.

5. Classroom management

The analysis revealed that the problem of classroom management in preparation programs is serious and needs to be addressed urgently. All the evidence in the analysis point to the role of classroom management in improving schools. Classroom management is about thinking and planning day-to-day practice in class (Bull & Solity, 1989). A behavioral model of classroom management is often associated with approaches designed to overcome both students' learning difficulties and behavioral problems. The model involves a complex set of tasks: preparing classrooms, lesson planning, procedures for record keeping, planning supervision duties, taking attendance, making seating charts, controlling classrooms, attending to supervision tasks, and so on. Apart from these, classroom management also involves disciplining student with dignity, working successfully with difficult students, reducing violence, aggression and hostility, reaching at risk students, and rediscovering hope for hopeless students (Curwin & Mendler, 2005). While preparation programs may be inadequate in this aspect of classroom management, effective teachers develop their own personal management practices without undue concern about the theories that underpin them (Laslett & Smith, 1984). However, every class being a mixed ability grouping of high-flyers and low achievers, it is important for teachers to early identify students with special needs, e.g. attention deficit disorders (ADD). The problem of classroom management needs to be addressed at two levels: at the level of preparation program for novice teachers and as a special needs education component in teacher development programs.

5.3 Other research findings and outcomes

In the process of the investigations and analysis of the data, this research study has identified a set of educational issues and concerns which will be presented in this section.

1. Compensation structure for teacher development

This study also proposes that professional development should be organized around a compensation structure to provide incentives to teachers to participate in meaningful professional development activities throughout their careers and develop lifelong learning skills. There is a need for a shift in policy reforms that can help promote professional development through incorporation of training attended to career ladder programmes. At present, seniority based on years of service is the most important criteria influencing one's prospects for promotion. This

needs to change if we want to value and encourage up-to-date knowledge, skills and qualifications. It is believed that a skills-based or competency-based compensation pay system might be a better way to value and reward teacher knowledge and skills. In such a system, teachers with more experience in classrooms and who have completed more professional development hours would get higher salaries. Such an approach would send the message to other teachers that new skills are needed and valued, that employers are willing to compensate them for committing the time to improve their skills, and that for schools to continue educating our children, teachers need to develop life-long learning habits to enhance their professional knowledge.

2. A case for the graduate teacher

This study has provided evidence to show that teachers are at the heart of any reform process in education. Teachers are the agents of change, and should be regarded as partners in efforts at reforming education. The movement toward the graduate teacher is the trend in teacher education worldwide. With the diverse changes taking place in education and the world outside, Mauritius enjoys the position to fully accommodate an all-graduate teaching force in its primary schools. As late as 2002, less than 17 % of primary school teachers were graduates, who received certificated teacher status from the MIE. Low pay, poor status and lack of interest in attendant responsibilities in respect of workplace learning tend to demoralize teachers to the extent that problems of burn-out, classroom fatigue and isolation tend to further increase frustration in the profession. Teachers need to be organized and motivated into initiating, sustaining, and directing activities leading to achievement, intrinsic and extrinsic motivation, locus of control, and most recently, attribution⁴ (Wittrock, 1986). Although, since 2002 initial teacher education (ITE) has moved from two-year Teacher Certificate to three-year Teacher's Diploma accreditation, there is a need for graduate teachers in the elementary school system for the implementation of the continuing professional development (CPD) schemes of Professional Development Schools (PDS). These, along with continuing professional development programs of PDS, should form part of teacher development programs for subject specialist teachers leading to a two-year B.Ed program conducted through on-line distance (ODL) mode jointly with the University of Mauritius and the Mauritius Institute of Education.

⁴ Student attribution is the study of students' perception of the causes of their successes and failures as learners.

3. Calculators in classrooms

The paradox in the Mauritian educational system is that while arithmetic calculators are formally prohibited in classrooms, there is a strong 'technopush' for computers in schools. According to The Technology Principle⁵,

'calculators and computers are reshaping the mathematical landscape, and school mathematics should reflect those changes. Students can learn more mathematics more deeply with the appropriate and responsible use of technology.... Technology cannot replace the mathematics teacher, nor can it be used as a replacement for basic understandings and intuitions. The teacher must make prudent decisions about when and how to use technology and should ensure that the technology is enhancing students' mathematical thinking.' (p. 1).

Calculators can sensibly be used to ease the computational process, although it needs not be used as a substitute for mental arithmetic. It is important that mental arithmetic should be prioritized over calculations that consume unnecessary time and energy. It needs not by-pass the instruction of basic arithmetic operations which are fundamental in understanding the algorithmic nature of machine processing. A recent review of national curricula for mathematics in European countries found that the arithmetic calculator is acknowledged in most classroom teaching, although its use is rarely prescribed or actively encouraged. (Ruthven, 1996).

4. Mathematical disposition

The traditional conceptualisation of mathematics as a large collection of concepts and skills to be mastered is giving way to a re-conceptualisation of mathematics as a domain, of mathematical competence as an instructional goal, and of the way mathematics competence should be acquired (Verschaffel & De Corte, 1996). There is general agreement that the instructional goals in mathematics education should be directed toward student learning that promote the acquisition of a mathematical disposition rather than a set of isolated concepts and skills. The notion of 'mathematical disposition' encompasses the acquisition of crucial aptitudes of competent learning and problem solving. These involve the ability to acquire domain-specific knowledge, heuristic

⁵ Available: <http://standards.nctm.org/document/chapter2/techn.htm>. Accessed March 7, 2005.

methods, metacognitive knowledge and skills, and affective components like beliefs, motivations and emotions, together with the ability to develop mathematical competence through the application of these categories integratively and interactively.

The National Council of Teachers of Mathematics (NCTM, 1989, quoted in Verschaffel & De Corte, 1996, p. 233) argues for a re-conceptualisation of mathematics learning:

“Learning mathematics extends beyond learning concepts, procedures, and their applications. It also includes developing a disposition toward mathematics and seeing mathematics as a powerful way to looking at situations. Disposition refers not simply to attitude but to a tendency to think and to act in positive ways. Students’ mathematical dispositions are manifested in the way they approach tasks whether with confidence, willingness to explore alternatives, perseverance, and interest and in their tendency to reflect on their own thinking.”

5. Curriculum needs of the information age

The postmodernist era has imposed new demands on teachers in terms of teaching styles, student learning outcomes, and curriculum objectives to meet the needs of the ‘Nintendo’ generation. A core curriculum for the information age learner should provide exercise in mental arithmetic, opportunities for concept formation and cognitive development through exploration, discovery, activity- and inquiry-based orientations. In particular, in the study of elementary mathematics, these meta-cognitive processes require a re-engineering of the mathematical concepts that are not only machine-treatable but also machine ‘processable.’ Additionally, a consideration of the concept of scaffolding (Vygotsky, 1978), within the Piagetian cognitive development perspective, delineates the epistemology of the logical-mathematical thinking into a continuum embracing mathematical concepts organized into a progression of levels: from concrete (also referred to as real), semi-concrete (or semi-real) to abstract, non-linguistic entities and that relate to the child’s maturation and operational unfolding, namely the pre-operational, concrete operational, and formal operational stages within the Piagetian ‘genetic epistemology’⁶ (Figure 2). The horizontal arrows show the different linkages and flow between the ‘hierarchical nature of mathematical concepts’ (Ernst, 1998) and the stages of operational thinking; the vertical bi-directional arrows establish a one-to-one mapping between the concepts and the stages of operational thinking.

⁶ The sensori-motor stage (0 – 2 years) of cognitive structures development takes the form of motor actions – this is being excluded as children of primary school age are the focus in the analysis.

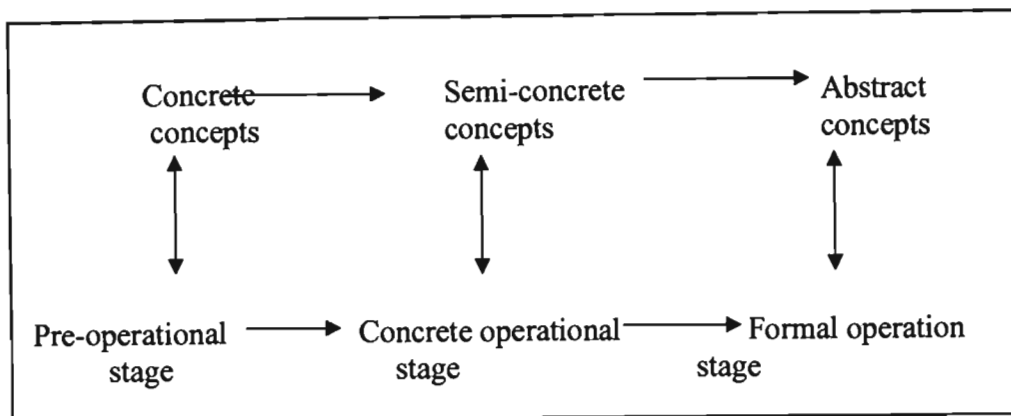


Figure 2. Relating Vygotsky's concept of scaffolding with Piaget's cognitive development theory

While the stages of cognitive development are associated with characteristics age spans⁷, each stage of the operational processes vary with individuals. Moreover, each stage is associated with a variety of structural forms covering classification and relations, spatial relationships, time, movement, chance, number, conservation, measurement and other meta-level operational processes of ordering, matching, partitioning, tracing and folding.

Traditional (mathematics) curriculum at the elementary level focuses on instruction of content through direct instruction, development of computational skills, and assessment through MCQs and written examinations. These have been, in their present form, the recipe of modernism in that they have been found to polarize the natural proclivities in the development of creative thinking skills based on an outdated, antiquated curriculum (Papert, 1980). From a solipsistic point of view, our conception of reality and knowledge, formal and informal, is an articulation of our 'sense making' for cognition through the processes of assimilation, accommodation, organization and equilibration (Piaget, 1978) within the tradition of a culture. Such an approach to the filtering of theoretical constructs of mathematical concepts tends to reduce the threat to the development of solution strategies and problem solving skills experienced by many children.

The educational challenge for professional development in the information age is to provoke an engagement with the deconstruction of the mathematical artifacts in order to reconstruct and reify the dialectical, dialogical and mediated nature of mathematical knowledge. A 're-engineering' of

⁷ Pre-operational stage: 3 – 7 years; concrete operational stage: 8 – 11 years; formal operational stage: 12 – 15 years

formal (elementary) mathematics curriculum is necessary to define a new taxonomy that identifies two distinct categories of mathematics – one that is procedural, conceptual, with an embedded time-dependent process, and therefore machine processable; the other being abstract and conjectural as is established in the canons of mathematical thinking. Such a re-thinking enjoins analyzing the content of traditional mathematics from a social constructive perspective, deconstructing its form with the possibility of embedding a time-dependent process and reconstituting it into a model that can be computer processed. The constitutive elements of machine-treatable mathematics embed modes of learning that foster activity-based learning, inquiry-oriented and discovery learning. These approaches promote multiple epistemologies of content and form, an attribute that fosters creativity and real mathematics conation.

6. Rethinking curriculum in the information age

There is general agreement that classroom instruction in the information age needs to incorporate materials for the Web in an effort to globalize the curriculum. Findings from research in educational theory and practice should guide instruction for teaching and learning to be effective. Learners of the post-modern era have developed altogether different learning styles, which are opposed to the structured linear learning characteristics of traditional school education. Educators and teachers alike recognize that change in teaching and learning styles impinge directly on every other aspect of school life and the process requires a restructuring of the curriculum to meet reform needs and the quality of education. Teachers are facing three major challenges: first, improving the quality of education in the context of educational reform; secondly, designing a curriculum that caters for the needs of a new generation of learners; and thirdly, how to bridge the gap between theory and practice.

The traditional curriculum has been blamed for many of the ills that have beset the present system of education, namely perpetuating the *status quo* in the system, providing education of a stereotyped nature, promoting unfair competition among children, and ignoring individual differences and mixed-ability. These have helped to reify the ‘social divide’ in the nation’s classrooms. It is the belief that learning will no more be the same with the advent of communication technologies in the schools. Already findings from research are bringing out new evidence on the impact computers have on the way teachers and students learn. According to Science for All Americans and other research (Backer & Saltmarch, 2000),

a significant issue in using technology in education is to integrate technology into curricula and demonstrate that it enhances both teaching and learning.

7. Curriculum analysis

An important aspect of this research has focused on analysis and evaluation of mathematics curriculum materials designed for primary school children. Deciding which curriculum materials to use is one of the most important professional judgments that educators make (Kulm & Grier, 2004). Curriculum development panels make recommendations that influence instruction for years to come (Kulm & Grier, 2004). But materials that tend to keep performance low for years, that teachers believe are unsuitable for mixed ability teaching, and that provoke high drop-outs, offer valid reasons for scrutinizing the quality of the materials to determine whether they are really responding to the needs of teachers, of schools and the community at large. If teachers have to make daily decisions about which teaching units or chapters to use and how to teach them, then an in-depth review of the content covered by a textbook may not be sufficient to determine whether the material will actually help students learn that content. Kulm and Grier (2004, p. 1) argue that “what is needed is a manageable process for examining curriculum materials that gets below the surface by focusing intensively on the appropriateness of content and the utility of instructional design.”

8. Characteristics of schools in the information age

The information age will very likely usher in a period where schools will be regarded as belonging to a community rather than being isolated from it. The participation of parents in school activities, for example, music day, Independence Day celebrations, theatrical/dramatic productions, etc., is likely to increase fairly rapidly. An extension of school hours in Mauritius, as recommended by the Pay Research Bureau (PRB), provides a unique opportunity for schools to include creative leisure time activities and thus integrate the school into the community. Such extensions offer opportunities for various kinds of aesthetic appreciations or expression to be absorbed into the school curriculum as well as offer teachers opportunities for professional development activities during the extended time.

9. Commonsense and prior knowledge state assessment

A fact quite often overlooked by teacher educators, especially when designing teacher education programs, is the prior knowledge of subject matter that pre-service or in-service teachers bring to their new learning situation. The importance of prior knowledge in adult education cannot be overemphasized. Dochy *et al.* (1999) define prior knowledge as the knowledge, skills or ability that students bring to the learning environment prior to instruction. The authors propose a model of learning in adult education which is influenced by several factors, one of which being prior knowledge state (pks). This state comprises existing declarative and procedural knowledge that is present before the implementation of a particular learning task, that is available or can be recalled or reconstructed, that is organized in structured schemata, and that is transferable and applicable to other learning tasks. It is relevant for the achievement of the learning task; and is dynamic in nature (Dochy & Alexander, 1995).

In the Dochy model, students themselves are responsible for formative assessment (prior knowledge state test and progress tests) which helps them to get started in their study and gives them the opportunity to monitor their progress. The question remains whether prior knowledge state assessment can be used as an instrument to facilitate and direct learning. Studies by Moerkerke (1996) have shown that the amount of prior knowledge has an important positive effect on study results. The studies also reveal that students, who take prior knowledge state assessment and receive feedback and study advice, had higher scores on final examination than non-respondents.

Understanding teachers' prior knowledge can help educators bring about transformation in teacher belief and develop teacher efficacy⁸ for their daily experiences. A case in point is the famous Gauss problem of finding the sum of the cardinal numbers from 1 to 100. At first sight, most teachers would undermine the problem as inappropriate or tedious for lower primary school children, while others might resort to their normal repertoire of '*artillerie lourde*'⁹ to use arithmetic progression summation techniques. In both cases, the precepts of prior knowledge are

⁸ Teacher's efficacy is described as 'the extent to which the teacher believes he or she has the capacity to affect student performance' (Bergman *et al.*, 1977, p. 137)

⁹ "*artillerie lourde*" is a French expression used here in a figurative sense to connote the unnecessary use of sophisticated mathematical techniques to solve problems that may in fact need a simplistic, commonsense approach.

untenable, yet Gauss solved the problem in a simple way that is evocative of the commonsense methods in the provision of special education (Westwood, 1997). Commonsense approaches are the product of the transformation of teacher's prior knowledge of problem solving strategies and development of an alternative pedagogy that is informed by research.

10. Principles of educational psychology in teacher education

Traditional preparation programs do not focus on the teacher's immediate instructional needs but rather foreground theoretical aspects of educational psychology rather than practice. As educators educational psychology is at the heart of effective teaching. Put another way, the claim in educational circles is that effective teaching should be based on sound educational psychology principles, but teachers find it hard to reconcile psychology courses offered by the education department with the subject area. There is empirical evidence that teachers learn more from clinical exposure, at the time of teaching practice in schools, than from lectures at training institutions. This attitude undermines the credibility of training institutions and puts into perspective their very *raison d'être* in preparing the nation's teachers. Furthermore, most studies in teacher education tend to sidetrack issues of curriculum relevance, theory-practice disjuncture, and overloading particularly affecting 'general purpose' teachers.

11. Teacher's attitude to the profession

Ideally, teacher's attitude to children, the school, and the community should be governed by a sense of reciprocity based on the changing needs and interests of stakeholders in particular and the motivations of the wider society in general. Teachers are found to take a purely instrumental view of their job and be more concerned with their own advancement than with education. They have been found to be pre-occupied with increasing their status, devoting more time to private tuition after school hours. Their all pervading idealism is that of possession of wealth which will open up endless opportunities for various forms of pleasure, possessions and pastimes (Hirst & Peters, 1975) in a society that is oriented towards consumption. Loyalty to schools is of minor importance when compared with concern for one's own career. Teachers' main concern is to get students to work that are manifestly related to the level of consumption, namely success in examinations. And students' perception of their education is also guided by the same spirit, that of surmounting series of hurdles in order to obtain a star school for their secondary education and well-paid jobs later in life. Such instrumental considerations tend to pervade (and perverse) the teaching profession and dominate life in schools.

Teaching jobs are seldom regarded as activities that can be pursued because of the challenge to the high standards set up in some schools, because of their obvious contribution to the good of the community, because of the opportunities for friendship and associations that they provide. Rather they are looked at as necessities to be endured for the sake of the money. The ever-present question in teacher's mind is "Where will this job get me?" The realization that one should delight in a job well done because of the opportunities for skill, creation and pleasure that it offers, because there is nothing more interesting to man than man, and because knowledge has a special attribute that it can be pursued for its own sake, should guide teachers if they want to make their working life more meaningful. Other considerations may be secondary or negligible.

12. Re-conceptualizing professional development within the postmodernist perspective

Postmodernism offers a systemic approach for re-conceptualization of professional development of teachers beyond the modernist view that focuses on the delivery of education as the additive sum of teaching strategies, learning skills, curriculum, modes of assessment, pedagogical content knowledge, and propositional knowledge. The postmodernist view holds that professional development as currently conceived – one week seminar, a day workshop, an occasional in-house training, complemented with hand-outs – is inherently aberrational in conception and misleading in approach because it does not frame up with teachers' needs in the context of emerging school reforms and the newer roles of teachers in the twenty-first century. The futility of the impact on teachers of such approaches is widely known. Darling-Hammond (1999, p. 221) argues that "schools must become dramatically more successful with a wide range of learners if many more citizens are to acquire the sophisticated skills they need to participate in a knowledge-based society." The fact is that the knowledge and skills of the modernist era have produced citizens that need continual re-training in the sophisticated skills accruing from emerging technologies of the last two decades if they are to remain productive and stay current with latest developments in their respective fields. With respect to the teaching profession, for too long teachers have been viewed as professionals with plug-and-play capabilities who could enter the profession for a life-time career span in schools. It is now felt that professional development should engage teachers in continuous and life-long learning processes for self-development and for growth in their profession.

13. Technology and professional development

The present information age has privileged the introduction of technology into classrooms. It is tempting for educators to use technology to innovate teaching and learning processes through access to a wide range of information and resources available through the Internet. Yet understanding technology and the learner is a critical variable in the equation of teacher development. Professional development backed by technology suggests a redefinition of teachers' development that goes far beyond the term 'training' with its implications of learning skills, and encompasses a definition that includes formal and informal means of helping teachers not only to learn new skills but to bring change and innovation (Grant, 1998). Stuart Mill was categorical on this issue: to teach John mathematics, the teacher must certainly know mathematics, but she should also know John. Teacher educators should *a priori* know and understand the learners, their needs and vocational sensibilities. To teach an would-be teacher it is necessary to understand the individual as much as to understand his or her future teaching needs and career trajectory that should be reflected in the design of teacher education programs.

Grant (1998) argues that because schools are increasingly investing in technologies for the classroom, it would not be possible to use such technologies to their fullest unless teachers are provided professional development to guide their use. Sending teachers to training sessions on specific technologies does not respond to their teaching needs nor do training in technology use are organized after assessing teacher needs. Too often sessions are conducted outside school hours without consulting teachers on their time availability. Such sessions fall short of teacher's expectations the more so as there are no follow-up into the classrooms.

Although teaching and learning processes are shifting from traditional teacher-centered to learner-centered paradigms, it is more than ever obvious that good teachers make good schools. Good teachers are the product of successful staff development practice which in turn helps to improve student achievement, and thus helps in building up the image of the school. Teachers take time to realize the importance of their own personal growth and development not until they talk and reflect about their practice. Their immediate concern on joining teaching is how well they can match classroom teaching requirements with the repertoire of lesson plans from preparation programs. Concern for career development precedes their concern for professional development. The latter is embraced at a much later stage in the equation of teacher development. Professional development aims to increase teacher's knowledge of, understanding

of, and expertise in their professional work, through activities designed to attain this goal (Morant, 1981).

There is a lack of a universal pattern in the duration of teacher education programs around the world. Many countries have a three-year diploma or four-year professional B.Ed degree that claims to offer adequate preparation to induct neophytes into the profession. Obviously, a two-year pre-service certificate course, as offered in the Mauritian context, is grossly inadequate to prepare an individual in the basic competencies and skills of primary education. Professional development can no more be seen as a panacea to heal a short-term ailment but needs to be addressed to offset negative tendencies that grow and develop within a school system. Our world picture of education and training has changed substantially over the past 20-30 years. We are presently experiencing a situation where technology has ushered in an era rich in change and innovation. This has led to a re-think of the role of schools and the learning environment, of educational system and societies, as much as to a re-conceptualization of the role of teachers, teaching, of learners and learning, of curriculum, and assessment in schools.

14. Curriculum of professional development programs

Wilheim *et al.* (1996) advocate that the curriculum of professional development programs offers teacher an opportunity to explore attitudes, develop management skills, reflect on the ethical implications of practice in classrooms with cultural compositions vastly different from their previous experiences. The form and structure of this curriculum causes teachers to step back and critically reflect on the nature of teaching strategies - not only on how they teach, but also on why they teach in a particular way.

Additionally professional development programs include curriculum renewal and restructuring, studies on errors and misconception in the process of concept formation, ideational scaffolding (Ausubel & Fitzgerald, 1965) that complements with antecedent learning. It should be pointed out that program evaluation has been labeled the “orphan” of teacher education (Galluzzo and Craig, 1990), as it is one of the poorest fields of interest in educational research in Mauritius. Even the Master Plan (1991, p. 90) spells out this limitation: “Teacher education programs have only occasionally been evaluated.” This shortcoming within the system may be attributed to the absence of an effective central body responsible for maintaining standards, for monitoring training methods, and for coordinating national policy. The MIE Act of December 1973 placed

the ultimate responsibilities, in the constituencies of teacher training, curriculum development and educational research, onto the MIE. Although the institution has enjoyed relative autonomy in matters of teacher education, there has been a lack of national direction for re-structuring MIE within the framework of an institutional reform plan to upgrade it to university status. Upgrading MIE to university status would not simply benefit teachers in a re-definition of their status, but learners joining teacher training institutions would do so in the hope to continue their university education and qualify as professionals, thus regarding their education as an opportunity to rise from their class (Willey & Maddison, 1971).

15. Integrating pedagogical features in Web-based learning

Open and distance learning (ODL) is Web-driven and offers itself as a new platform for the delivery of instructional materials to non-traditional learners (off-campus) dispersed in time and space. A new platform also requires a new definition of the learning environment it creates and that is often grounded in a new paradigm of learning, particularly when technology becomes the driving force of the innovation. It would be for the purveyors of instructional curricula to determine this new, emergent paradigm of learning and not for technology to decide on the pedagogical strategies to be incorporated in such environments. Clearly, technology can mediate flexible modes of course delivery. Amory (2004, p.1) argues that “technology has been successfully used in training programs where participants learn narrowly defined, task-oriented function.” However, in other modes of application, for example as a learning tool, technology has not lived up to the mark. “... [M]any past experiences show that technology has had little, or no, effect on the ability of students to understand new concepts or to develop critical problem-solving skills” (Amory, 2004, p.1). However, technology can still determine to a large extent the quality and ‘texture’ of computer-based learning in distributed learning environments that foster learner-centered approaches. Assuming that technology can purvey all the elements of teaching and learning as envisioned by traditional learners (on-campus), there is as yet a need for a self-explaining interactive environment that can foster constructivist learning and reflection as well as promote deep learning in the next generation of highly interactive computer-based environments (Mayer *et al.*, 2003). Such setting is characterized by an approach that is ‘learner centered’ with open access and is expected to engage learners in ‘self-instruction’, ‘open and flexible learning.’

According to the Commonwealth of Learning (2000), a ‘learner centered’ system of education ensures the integrity and freedom of individual learners; the instructional process offers flexibility

in the sequencing of lessons while objectives, content, learning methods, and methods of assessment are negotiated with learners. The term 'open access' implies the absence of formal control in the form of entry requirements, entrance examinations or other forms of constraints or restrictions to learners having access to materials available in distance mode. The term 'self-instruction' refers to a process in which learners have control over the instructional process. 'Open and flexible learning' is characterized by a learner-centered philosophy of education that emphasizes giving learners choices about place of study, whether at home, in the workplace or on campus; pace of study, whether self-paced or cohort-paced; support mechanisms, whether tutors on demand, audio conferences or computer-assisted learning.

Technology diffusion of learner-centeredness provides an orientation towards the construction of learning communities in which every participant is a stakeholder. According to Bober and Dennen (2001), instructional settings that are community-oriented make learners feel connected to their peers, their instructors, the larger school administration and the neighborhoods where they work and live. Learning in such communal settings encourages positive attitudes towards errors, omissions, and even deficiencies to be treated as common human problems, as learning opportunities for collegial endeavor towards more understanding, "without negating or discounting behavioral norms and expectations" (Bober & Dennen, 2001, p. 242).

16. ICT for children

Education of children entails an educative process that goes beyond the developmental stages of the Piagetian genetic epistemology. A basic premise of children's cognitive development, evidenced from the ethnomethodological context of this study, points to the fact that children require to be literate and numerate in the fundamentals of the three R's, viz. Reading, wRiting and aRithmetic for development of memory, reasoning and recognizing relationships and making connections with other kinds of thinking, before initiation into computer or technological literacy. All the evidence point in the direction of children's development in the three R's first, followed by a brief introduction to the desktop computer by way of demystifying the innovation, followed by computer literacy (CR) in late adolescence. The learning curve for ICT has a steep segment that accommodates development of computer knowledge and skills within a surprisingly short time span and that can be fairly easily wedged into the upper school curriculum at any reasonable point as co-curricular or extra-curricular component of learning.

17. Political will

The issues addressed in this study revolve around the phenomenon of change. Change is the only constant factor in this century, yet change may inspire the highest hostility in favor of perpetuating *status quo* or protecting vested interests. Change also engenders economic and financial implications, but implementing change as an outlay or investment has economic and societal returns with long-term pay off that only few can envision in the educational decision-making and planning process. In this sense, the issue of political will for change implementation is considered a non-issue.

5.4 The Recommendations

The following are the main recommendations that have accrued from this study:

- I. Set up Professional Development Schools (PDS) within the Mauritian school education system for the purpose of organizing and conducting school-based continuing professional development (CPD) of practising teachers.
- II. Set up School Improvement Committee (SIC) within Professional Development Schools to organize teacher development activities and monitor progress. Members of SIC to be given reduced 4-day week teaching workload. Members to consecrate the 5th working day mentoring trainee teachers, conducting curriculum reviews, and promoting school-based action research for other members of staff. Employment of 'floating' teachers to replace SIC members involved in teacher education activities.
- III. Provide teachers in Professional Development Schools with computers and Internet facilities.
- IV. Re-introduce the subject (specialist) teaching formula in primary schools. Teachers with general purpose status to move on to subject teaching category after successful completion of professional development programs conducted by SIC.
- V. Subject (specialist) teachers to follow B.Ed programs using online distance learning (ODL)

mode with the Mauritius Institute of Education. The ODL system to incorporate elements of online collaborative learning with focus on quality (as detailed out in section 2.5.2).

- VI. Open enrolment to primary school teachers with Teacher's Certificate Primary and Advanced Certificate in Education to upgrade to 3-year Teacher's Diploma Primary.
- VII. Schools to address diverse student needs by raising the general level of achievement of all students through systemic reform to focus on (i) improving overall quality of schooling for all children, (ii) reducing inequalities, (iii) developing instructional support system to ensure early identification of students at risk and to provide for remedial action.
- VIII. Set up regular workshops for teachers to promote technology in teaching.
- IX. Set up technology education workshops to support/reinforce regular and remedial classes.
- X. Each school to prepare a report card with classified and categorical data on its academic performance, staff movement and assignment, and overall school achievement in the promotion of community life.
- XI. Restructure teacher training within the framework of an institutional reform plan to upgrade the Mauritius Institute of Education (MIE) to university status.
- XII. The MIE to introduce online distance learning (ODL) facilities for its in-serve courses to promote continuing professional development of teachers in collaboration with Professional Development Schools. This aspect of MIE-school collaboration in teacher development provides a unique way to reinforce the MIE-school link.
- XIII. Motivate teachers to make extensive use of World Wide Web (WWW) resources in globalizing instruction and curriculum. Being an island isolated in the Indian Ocean, the World Wide Web offers the best opening to the world outside for learners to share ideas and thoughts.
- XIV. A basic premise of this report is that we must restructure the elementary mathematics curriculum – both what is taught and the way it is taught. If our children are to develop the

mathematical knowledge needed in the twenty-first century, we need to redesign the content of school mathematics and the way it is taught. The curriculum restructuring will also need producing new textbooks within the framework of a global curriculum and retraining teachers in the pedagogy that will be the dominant paradigm of instruction in the twenty-first century. Curriculum development should be viewed as an intellectual engagement requiring teachers not only to know their content but also to acquire curriculum planning skills.

- XV. Calculators to be used in classrooms to ease unnecessary calculations that are cumbersome for the mental process.
- XVI. To develop a national curriculum standards and framework for schools. The main objectives of the national curriculum are (i) to establish standards, (ii) to establish an entitlement for all pupils to a number of areas of learning and to their self-fulfillment and development as active and responsible citizens, (iii) to promote curriculum continuity and coherence in the transition of pupils between primary and secondary schools and phases of education, (iv) to promote public understanding of the work of schools and in the learning and achievement resulting from free and compulsory education.

5.5 Evaluation of the proposals

The researcher presented the suggestions and proposals formulated in this research to the director of the Planning and Project Analysis at the Mauritian Ministry of Education & Scientific Research. On the issue of setting up Professional Development Schools (PDS), the ministry's criteria for appointing schools as PDS will be on the basis of individual school's performance and their histories of track records, thus providing opportunities to all schools to compete for PDS status. On the question of using distributed learning for upgrading teachers to graduate status with the collaboration of the Mauritius Institute of Education, the issue of teachers' ability to use technology for their own upgrade as well as in teaching was raised. It was pointed that the Mauritian National Productivity and Competitiveness Council (NPCC) has provided extended training in Information and Communications Technology (ICT) to the bulk of primary school teachers (around 7000), so that the problem of using technology in teaching and for personal upgrade in distributed learning environments no more posed a problem. It means that most of the teaching personnel in schools are not only computer literate but have acquired proficiency in using technology in teaching.

The project of Open and Distance Learning (ODL) and use of Open learning Systems was embedded within the context of the School IT Project. In this context, the ministry is planning to provide 50 schools (out of a total of 256) with computer laboratories in the course of the present year (2005), with identical provisions extended and phased over to 50 other schools each financial year until 2009. It is the ministry's firm intention to upgrade all primary school teachers to graduate status as proposed in this thesis. There was agreement with the view that teachers in schools are better at capacity building of their peers than teacher educators who were unfamiliar with the needs of classroom teaching. The goal is to move towards bringing parity in job and salary conditions between teachers in the primary and the secondary schools. (This research study pointed out the poor status of primary school teachers.) Another objective is to form a pool of teachers in the primary schools who may be seconded for teaching in scarcity areas (Design and Technology, Music, Arts, oriental languages, etc.) in secondary schools. The ministry's plan is to foster interaction between primary and secondary school teachers in increasing mobility in both directions to palliate the problem of teacher shortages in scarcity areas.

On the issue of curriculum restructuring as proposed in this thesis, the ministry's view is that the paucity in our school curriculum was largely due to a lack of professionalism and know-how among curriculum writers who constituted the writing panel at the Mauritian National Centre for Curriculum Development and Research (NCCRD). It is felt that there is a need for trained curriculum personnel who could review and rewrite the school textbooks to reflect modern trends in curriculum development and to provide for learners in the information age. It was observed that children in the lower primary who scored fairly well in continuous assessment were found to perform poorly in the upper primary levels, especially at Standard IV and V. This was in agreement with the findings that the lower primary mathematics textbooks based on activity-based and inquiry models of learning were more pedagogically sound in promoting learning than the problem-solving focus emphasized in the upper primary textbooks. According to the director of Planning and Project Analysis, it was impractical to recruit curriculum developers from overseas because of cultural and language problems. Overall, there was consensus and convergence of views with regard to all the issues researched in this thesis.

5.6 Conclusions

The study aims at investigating how school performance is affected by inadequate teacher preparation coupled with absence of continuing professional development (CPD), and conversely how technology may become instrumental may be utilized to build communities of learners to foster workplace learning. The current view on teacher preparation reflects teacher's role in the broader perspective of post-modernism and developments taking place as a result of the paradigm shift in education (Kuhn, 1962). These philosophical approaches provide a re-conceptualization of the role of teachers in their capacity to succeed at teaching more challenging content to more diverse students and bring in focus a globalized curricula where teachers are no more regarded as the instructivist (Bruner, 1966) or technical rationalist (Schön, 1986), but facilitators and mediators in the teaching-learning process. It is also becoming increasingly clear that the focus on teacher development is to prepare teachers for positions of responsibility in relation to the schools, within the community of learners, and society in general. In this perspective teacher development programs must inevitably go beyond the mere provision of immediate classroom basics; it must develop the full potential of the would-be teacher who will be looked upon as shaping and molding the society of the future.

School improvement is a systemic process. There is a need for a comprehensive approach that includes continuing professional development through creation of a professional 'community of practice' to break teacher isolation. In this respect, computer technology takes on a new role to integrate professional development and teacher learning. The proponents of reform regard computer technology to be a powerful tool that can bring change in the quality of education. Teachers are at the heart of the reform in education. It is important to understand that before technological innovation enters schools, teachers need to experience learning in computer-based environments. It is only then that they can internalize its aims and transform the learning for their students.

The changing nature of learner's demands, economic pressures, technological developments, and the critical increase in the mass of learning population in this century, definitions of what constitutes education and training are changing. The emerging technologies have contributed in strengthening the belief in the importance of the link between educational investment and economic growth and development. The massive investment in education through the provision of new technological infrastructures has opened up new opportunities for today's students. The

use of distance learning technologies, and more specifically distributed learning, are proving to be tools of the twenty-first century that will revolutionize the delivery of education and training.

The need for professional development of teachers has not received adequate attention at the hands of bureaucracies and policy-makers. In this sense, teachers feel that they have been regarded as a 'neglected species.' If teacher educators are in a way largely responsible for their own professional development and upgrade, the same is not applicable to practicing teachers. Teachers' workload and daily schedule cannot accommodate slots for formal developmental activities. In brief, this thesis is for restructuring teachers' workload to incorporate free slots that can be used for meaningful teacher development activities leading to their professional upgrade. To work with children, teachers need new opportunities to develop, master, and reflect on new approaches.

Elementary school mathematics comprises specialized form of knowledge that are institutionalized in textbooks and syllabuses. Textbooks produce activities (Romberg, 1986). In the analysis of textbooks, the researcher has revealed a number of features of their structural levels, their mode of working and organization in terms of thematic weights. The didactics of mathematics is no definite fixed body of knowledge (Becker & Selter, 1966). It is true we need to know more about learning, but, as Romberg and Carpenter (1986) argue, we need also to know more about what teaching is doing to learning. Assuming that analyzing the textbooks is explicitly biased in exposing pedagogic structures rather than the didactics of mathematics, the latter represents the activities and practices that belong to the esoteric domain regulated by the realities of subject discipline.

The mathematics curriculum in our schools is hyped to benefit 'high ability' students and to be largely responsible for overall low performance. Teachers must select appropriate and interesting mathematical tasks to engage students' interest and intellect. An important task is to seek connections to previous information. The teacher should provide every student with opportunities to deepen their understanding of mathematics by engaging them in meaningful activities through approaches such as activity-based learning, discovery learning, inquiry based learning, and learning through play. In this respect, technology is considered to be an important 'agent' in helping students to pursue mathematical ideas.

Appendices

Appendix 1: Teacher's Certificate Primary (TCP) course structure:

Teacher's Certificate Primary (TCP) programme comprises the following modules:

- 1) English
- 2) French
- 3) Mathematics
- 4) Science Studies
- 5) Computer Studies
- 6) Design and Technology
- 7) Food Science nutrition
- 8) Music
- 9) Art
- 10) Creative Education
- 11) Physical Education

Appendix 2: Adult development theory

Theories about adult development have been grouped under four models – biological, psychological, sociocultural, and integrative (Merriam and Caffarella, cited in Imel (2001)). The biological model is concerned with how physical changes affect development, while the sociocultural model represents new ways of thinking about the influence of adult development on adult education. The integrative model examines how the three other models of adult development intersect and influence each other. Another area receiving considerable attention in the study of adult development is the transformative learning approach. According to Dirkx (cited in Imel (2002)), this approach is about making changes through transforming one's perspectives or meaning; making senses of these changes frequently involves development. In perspective, education is viewed as a transformational process, suggesting it is a way that adults make meaning from their lives.

Appendix 3: Educational technology

The word “technology” is derived from the Greek word ‘technic’ meaning art or skill and ‘logia’ meaning science or study. Thus technology is the science of study or an art or skill.

Technology, as a creation of the human kind, is most often associated with physical devices because they are concrete and tangible. Yet, technology is far beyond mere artifacts; it can be intangible, invisible in nature. The physical parts are the hardware i.e. the ‘hard’ components, while the intangible parts are the software, i.e. the ‘soft’ components of technology. As an object of human creation, every hardware requires a set of techniques, procedures, or methods for handling and manipulation with the result that the set of procedures become an integral part of that technology’s software. Such procedures associated with the software become enshrined as traditions, cultures, regulations, roles, and occupational skills (Kearsley, 1984).

Technology and its potential have often been associated with improvements in productivity in areas of agriculture, manufacturing, transportation, and communications. It has also assumed important developments in the areas of weaponry and warfare. Only in the past two decades that education and training have adopted technology as a means to improve “instructional productivity” (Kearsley, 1984, p. iii)

Appendix 4: E-learning

E-learning refers to an approach to facilitate and enhance learning by means of personal computers, CDROMs and the Internet (Wikipedia, 2004). It includes email, discussion forums, and collaborative software. Though characterized by facilitation such as asynchronous learning, courses being tailored to specific needs and just-time learning, e-learning may also be used to support distance learning through the use of computer networks, namely the Internet. It may also be considered to be a form of flexible learning. Often, but not always, e-learning will also attempt to be a student-centered, in that it focuses on the needs of the student, rather than those of others involved in educational processes, such as teachers and administrators. The approach has many implications for the design of curriculum, course content, and interactivity of courses. For instance, a student-centered course may address the needs of a particular student audience to learn how to solve some job-related problems using some aspects of mathematics. In contrast, a course focused on learning mathematics might choose areas of mathematics to cover and methods of teaching which would be considered irrelevant by the student. Some view e-learning as a means to *effective* or *efficient* learning, due to its ease of access and the pace being determined by the learner, but to date little research has reinforced this (Wikipedia, 2004).

Not every e-learning resource, usage or provision is necessarily 'exclusively e-learning', sometimes a hybrid 'blended-learning' solution is available, either combining distance learning with direct contact 'close at hand' human educational resources, or combining software driven resources with human intervention (whether remote or local, computer mediated (such as through email or 'chat) or non-computer mediated (such as face to face or telephone) or combining software driven resources with any other educational resource (TV, radio, books, tapes, etc.)

On the practical side, some e-learning is about organizing the topics to be taught and creating multimedia CDROMs or web sites. In higher education especially, the increasing tendency is to create a Management Learning Environment (MLE; also called a Virtual Learning Environment, VLE) in which all aspects of a course are handled through a consistent interface, using specialized software that is standard through an institution. Commercial tool for constructing MLEs, such as WebCT and BlackBoard are now gaining wide use in universities and other higher education institutions.

Appendix 5: Adult learning

Malcom Knowles (cited in Lieb, 2004) identifies the following characteristics of adult learners:

- Adults are *autonomous* and *self-directed*. They need to be free to direct themselves. Their teachers must actively involve adult participants in the learning process and serve as facilitators for them. Specifically, they must get participants' perspectives about what topics to cover and let them work on projects that reflect their interests. They should allow the participants to assume responsibility for presentations and group leadership. They have to be sure to act as facilitators, guiding participants to their own knowledge rather than supplying them with facts. Finally, they must show participants how the class will help them reach their goals (e.g., via a personal goals sheet).
- Adults have accumulated a foundation of *life experiences* and *knowledge* that may include work-related activities, family responsibilities, and previous education. They need to connect learning to this knowledge/experience base. To help them do so, they should draw out participants' experience and knowledge which is relevant to the topic. They must relate theories and concepts to the participants and recognize the value of experience in learning.
- Adults are *goal-oriented*. Upon enrolling in a course, they usually know what goal they want to attain. They, therefore, appreciate an educational program that is organized and has clearly defined elements. Instructors must show participants how this course will help them attain their goals. This classification of goals and course objectives must be done early in the course.
- Adults are *relevancy-oriented*. They must see a reason for learning something. Learning has to be applicable to their work or other responsibilities to be of value to them. Therefore, instructors must identify objectives for adult participants before the course begins. This means, also, that theories and concepts must be related to a setting familiar to participants. This need can be fulfilled by letting participants choose projects that reflect their own interests.
- Adults are *practical*, focusing on the aspects of a lesson most useful to them in their work. They may not be interested in knowledge for its own sake. Instructors must tell participants explicitly how the lesson will be useful to them on the job.
- As do all learners, adults need to be shown *respect*. Instructors must acknowledge the wealth of experiences that adult participants bring to the classroom. These adults should be treated as equals in experience and knowledge and allowed to voice their opinions freely in class.

Appendix 6: The Japanese ‘Open Approach’ project

The project required that lesson plans were organised as follows:

- Introducing the problem;
- understanding the problem;
- problem solving by individual children;
- comparing and discussing children’s solutions, methods, and formulated problems;
- summarizing by the teacher.

Further, an alternative approach to assessment of children’s learning was devised (Becker & Selter, 1996). Teachers collect assessment information by examining pupils worksheets, by purposeful snaning of pupils’ work while work on the problem, and by observing when the teacher facilitates pupils’ discussion of their own self-constructed methods. A student’s work is assessed in terms of

- fluency – the number of correct solutions, methods, formulated problems (quantitative);
- flexibility – the different mathematical ideas that are discovered (qualitative or quantitative);
- originality – unique or original ideas that are generated; and
- elegance – the expression of children’s thinking in mathematical notation.

The project focused on mental arithmetic. For example, after children have begun to learn addition of whole numbers, they are asked ‘How can you find the answer to $8 + 7$?’ There can be many responses, such as counting from one; counting from nine; decomposing 8 to $(5 + 3)$ and 7 to $(5 + 2)$ to get $10 + 5 = 15$; decomposing 7 to $(2 + 5)$ to get $(8 + 2) + 5 = 15$; thinking $8 + 8 = 16$ and $16 - 1 = 15$; or thinking $7 + 8 = 14$ and $14 + 1 = 15$. The different ways are compared and critiqued by the children. The Japanese work represents an interesting and important use of ‘openness’ of problems in mathematics teaching. The process is open, the outcomes are open, and the ways of formulating problems are open (Becker & Selter, 1996).

Appendix 7: The Comprehensive School Mathematics Program

The program integrates the study of numeration, number sense, estimation, patterns and relations, geometry and measurement, probability, statistics, algebraic and algorithmic thinking and making connections in mathematics. Calculators and computers are used to enhance learning and understanding.

The content of the project extends children's real-life and fantasy experiences using a 'pedagogy of situations' – children are taken through sequences of problem solving experiences in game-like and story contexts.

At each grade there is a prescribed schedule of detailed lessons in the Teacher's Guide; a typical lesson includes a whole-class discussion of a problem situation and group work with different worksheets, in increasing order of difficulty that permits individualization.

Appendix 8

Questionnaire A

(Teacher’s Certificate Primary)

You are kindly requested to fill in the questionnaire below. The information provided will be kept confidential and will be used solely for educational research. The purpose of the questionnaire is to determine the competencies and skills that you have acquired in following the Teacher’s Certificate Primary (TCP) course which is nearing to its end. Please fill in the blank space or tick the boxes, as appropriate.

Thank you for your collaboration

A. Personal and professional details

1. (a) Gender: Female☐ Male ☐

(b) Your age: years

(c) Do you have a diploma/diploma? No ☐ Yes ☐

If ‘Yes’, state your diploma/degree:

2. Do you own a computer? ☐s No ☐

3. If ‘No’, do you have access to a computer (e.g., in a cybercafe)? Yes☐ No ☐

B. Skills in communication

The TCP program has helped me

	Agree	Disagree	Not sure
1. to improve my written English/French			
2. to improve my spoken English/French			
3. to communicate fluently and coherently			
4. in writing reports, giving presentations			

C. Curriculum planning and instruction

I have acquired the basic competencies in

	Agree	Disagree	Not sure
1. how to prepare content-specific lesson plan			
2. the content of the primary curriculum			
3. how to develop a coherent strategy which implements the curriculum through appropriate methods of teaching and assessment			
4. setting up of group for collaborative learning			

D. Student evaluation

I have acquired the competencies in

	Agree	Disagree	Not sure
1. formative assessment			
2. summative assessment			
3. managing continuous assessment			

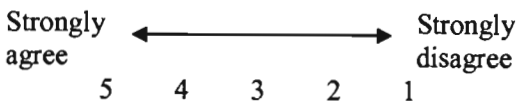
E. Diagnosis of learning difficulties

I know how to develop and implement strategies for

	Agree	Disagree	Not sure
1. differential teaching			
2. individualized instruction			
3. collaborative group work			

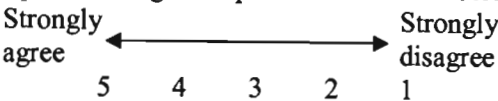
F. Classroom management

I have learnt new skills in classroom management



G. Computer skills

I have acquired enough computer skills to be labeled Computer literate



Prem Moorgawa
TCP Subject Coordinator (mathematics)

9 May 2002

Appendix 9

Questionnaire B

The purpose of this questionnaire is to determine the extent to which the MIE Teacher's Certificate Program (TCP), including the components relating to your mathematics courses, has contributed to your teaching in primary school classes. Please tick/circle your answers as appropriate. The information provided will be kept confidential and will be used solely for educational research.

Thank you for your collaboration

A. Personal and professional details

Name of school:

5

1. (a) Gender: Female:
 Male:.....

(b) Your age: Under 30 yrs.....
 30 - 39 yrs
 40 - 49 yrs.....
 50 - 59 yrs

(c) Teaching experience (in years):

2. Do you have a diploma/degree Yes:

No: (Tick as appropriate)

State your diploma/degree:

3. The standards you have taught

Std 1 – III: No. of years

Std IV – VI: No. of years

4. Are the pupils at the school streamed by ability?

Yes.....

No.....

5. Do you regularly take pupils out of the school/class for outdoor activities as part of your normal teaching activities?

Yes.....

No.....

*For
computer
use
Code 1 -
number*

1
2

1
2
3
4

1
0
1

1
2

1
0

1
0

6.To teach basic maths concepts, I more often		
• use ideas from prescribed text books		1
• use my own teaching materials		2
• improvise in the classroom		3
• a combination of above		4
7. Do you require that your pupils know their multiplication tables off by heart?		
Yes.....		1
No.....		0
8. Teaching sometimes require reference materials. Do you normally		
• supply most of the materials for your pupils		1
• ask the pupils to find their own.....		2
9. The subject teaching formula was dropped in 1994. Would like it to be reinstated now?		
No		0
Yes.....		1
If no, why?		
.....		
If yes, why?		
.....		
10. Do you regularly give your pupils homework?		
Yes.....		1
No.....		0
11. The trend in primary school teaching is for teachers to involve children in constructive and creative activities.		
Specify one activity/topic in mathematics that you taught/introduced and that you would describe as constructive/creative		1
Specify one activity in general in which you involved your pupils and that you would describe as eliciting their aesthetic expression:		1

B. Skills & Competencies in mathematics instruction*(In these sections, please circle the appropriate code number)*

12. The TCP has helped me For computer use

Code Number	Agree	Disagree	Don't know	
1. To teach mathematics effectively in lower primary		2	3	20
2. To teach mathematics effectively in upper primary		2	3	21
3. To develop teaching aids for math instruction		2	3	22
4. To use teaching aids effectively		2	3	23

C. Skills in communication

15. The TCP program has helped me

	Agree	Disagree	Not sure	
1. to improve my written English/French	1	2	3	24
2. to improve my spoken English/French	1	2	3	25
3. to communicate fluently and coherently	1	2	3	26
4. in writing reports, giving presentations	1	2	3	27

D. Student evaluation

17. I have acquired the competencies in

	Agree	Disagree	Not sure	
1. formative assessment	1	2	3	28
2. summative assessment	1	2	3	29
3. managing continuous assessment	1	2	3	30

E. Curriculum planning and instruction

*For
computer*

16. I have acquired the basic competencies in *use*

	Agree	Disagree	Not sure
1. how to prepare content-specific lesson plans	1	2	3
2. the content of the primary curriculum	1	2	3
3. how to develop a coherent strategy which implements the curriculum through appropriate methods of teaching and assessment	1	2	3
4. setting up of group for collaborative learning	1	2	3

31

32

33

34

F. Diagnosis of learning difficulties

18. I know how to develop and implement strategies for

	Agree	Disagree	Not sure
i.. differential teaching	1	2	3
ii.. individualized instruction	1	2	3
iii. collaborative group work	1	2	3

35

36

37

G. Classroom management/General

19. Do you usually allow your pupils to move around the classroom?

Yes..... /No.....

38

20.I usually talk to a colleague or refer to the headmaster to deal with undisciplined pupils:

Yes..... /No.....

39

21. Do you own a computer? Yes: / No:.....

40

If No, do you have access to a computer: Yes...../No.....

[22 – 27, please circle the appropriate code numbers:
Strongly disagree = 1, Disagree = 2, No opinion = 3, Agree = 4, Strongly agree=5]

22. I have learnt new skills in classroom management

Strongly disagree ← Strongly agree
1 2 3 4 5

41

23. I have acquired computer skills to be labeled Computer Literate

Strongly disagree ← Strongly agree
1 2 3 4 5

42

24. The MIE TCP program influences my classroom instruction in primary schools.

Strongly disagree ← Strongly agree
1 2 3 4 5

43

25. I base my teaching of basic concepts in math on the prescribed text books

Strongly disagree ← Strongly agree
1 2 3 4 5

44

26. The MIE TCP program prepares a teacher for a life-long career in primary school education

Strongly disagree ← Strongly agree
1 2 3 4 5

45

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE
If you would like to make additional comments, or elaborate on your answers,
please write on the verso. I should be grateful for your comments.

P. Moorgawa
Dept. of Mathematics & Computer Education

Appendix 10: Focus group interviews

1. Focus group interviews (pre-service teachers)

Target audience: Four trainee teachers interviewed at the end of preparation programs.

Pseudonyms: Wendy, Sharon, Karen, Pamela

Question: *You have completed your Teacher's Certificate Primary (TCP) Program at the end of two years of face-to-face courses and teaching practice in schools. What would you say about the teacher education program, the ICT component, and your level of preparedness to teach elementary school mathematics?*

Wendy

I would like to compliment the tutors for the wonderful coaching during the two years at the MIE. We learnt to understand student needs and how to face the challenge of teaching especially in the lower classes. As adults we had vague ideas about what we thought we knew about elementary school *mathematics*. In general, the face-to-face sessions, especially the lecture part, seemed to be teacher-centered. The views and beliefs of the tutors were understood to be the most important. Our views on certain topics were hardly ever sought. We have some prior knowledge which we thought could be useful in the discussions, but we realized that there were a lot more to learn from the face-to-face sessions. Our prior knowledge was not considered during the discussions and so were not taken on board. The discussions were particularly useful as it was the only time we could reflect on the instruction. Active participation in discussions meant that learning was taking place. We believe that trainees can contribute to the pedagogy of the elementary mathematics. We learnt many things about the use of *teaching aids*, how to improvise and use them for concept formation. We had to design teaching aids while designing the *lessons plans*. Of course, the *tutors* showed us some of their own. We understood their use and relevance to concept formation, but, at times, teaching aids that appeared practical to adults was too abstract for children. For example, in teaching line symmetry, the teacher designed a 'paper heart' to represent the human heart. I wonder if children can conceptualize the meaning of a paper heart and relate it to symmetry. The tutor's approaches to teaching some mathematical concepts were very interesting but did not meet the realities of the classroom. They were not prescriptive, but we learnt that there was always an alternative, perhaps better way of doing the same things.

The lesson plans were the strongest points in the course. The emphasis on designing lesson plans was particularly helpful. We came up with several approaches to designing lesson plans in

preparation for future classrooms practice. By the end of the program, we developed a repertoire of lesson plans that we hope will be utilized in actual classroom teaching.

A point worth mentioning is the pace of lectures. Most found the pace of lectures or lecturers too fast to keep up with the curricular materials being presented. There was no opportunity to come back again to those materials. There is a need for increasing the number of tutorials to enable trainees revisit certain areas of the instructions which appeared hard but interesting. We need more tutorials and less lectures. We have individual differences of our own. We were more comfortable with morning lectures. Afternoon lectures were rather boring and dull. Free times for library or research works were limited. Lectures in the form of face-to-face sessions were prioritized. The content of primary mathematics was very vast and far too much for a two year course. The tutors seemed to be rushing against time to complete the preparation program. There were too many lectures and few tutorials. The courses were lecture centered. We had no opportunity to discuss the tutor's methods. The pedagogy part was frustrating. It was the teacher's views that were privileged. Regarding the theoretical part of the course, the overemphasis on Piaget's developmental psychology seemed to permeate every aspect of concept formation. Why no mention of technology in concept formation. ICT was the poor child of the whole program. The ICT course was completely detached from the realities of the classroom. Instead of using ICT to explore basic mathematical concepts, we learnt more about the various part of a computer and applications of the computer. The application of Office tools were only for word processing, some spreadsheet, again these were alien to the mathematical concepts. We had hoped to learn how to use the computer to explore, to investigate, basic concepts, but we spent time learning about the car, rather than driving it.

Sharon

The elementary mathematics part of the training program was an occasion to learn about the content of primary school mathematics. It was not that simple as we at first thought about it. Too much content was covered in a short while. The tutors seemed to be in a race against time. There was not opportunity for discussing ideas. The tutor's views seemed to predominate. The course was teacher-centered, ideas were following in one direction only. We were at the receiving end and had no opportunity to discuss the tutor's views nor own views. We think we have some knowledge about elementary mathematics. But these were ignored and it was the tutor's views that prevailed. The extent of knowledge coverage of the mathematics program was meant for an

undergraduate program, not a certification course. Too much was covered for a two-year program.

The part to do with craft knowledge, that is the pedagogical aspect was teacher centered. Our tutors showed us models of lesson plans. Only the structures of the plans were highlighted. I mean we were showed how to write the aims, objectives, how to use teaching aids, procedures, assessment and make relevant comments. I think we used those same structures to design our lessons plans. It worked fine. Only of the content of lesson plans varied from lesson to lesson, while the structure remained the same, stereotyped like. We consider this to be strong points in our training program. The weak points in our preparation program have been no doubt the free distribution of hand-outs to supplement lecture notes and the pace of the lectures. Although the intention behind giving hand-outs was laudable, it could not be ascertained that the hand-outs were really read. We felt that the lectures were important and relevant materials, whereas hand-outs were intended to cover side information not covered in lectures. The question we always asked was: Were the hand-outs relevant to examination, or were they meant to ease the work of the lecturer. I am sure there was always some confusion regarding hand-outs. The tutor was really a facilitator who, at the end of the day, wanted to ease the burden of copying by supplementary notes with hand-outs. The lectures were conducted in the most unprofessional way. It was a one way traffic: from the teacher to the students. No opportunity for discussions. Lectures were simply dished out to us in a manner that gave the impression that the whole process of teacher education was to throw out content knowledge to passive trainee students. The craft knowledge, i.e. the part dealing with the art of teaching was the weakest. Teaching adults is not the same as teaching children. We were treated as children. There was no opportunity to design and try our own approaches to concept development in the basics of elementary mathematics. It was always Piaget's methods that dominated the pedagogy part of the mathematics classes. Our views were not entertained nor ever invited any discussions.

The ICT segment of the program was the least unrealistic. We learnt more about the computer, its various parts, how they function, than how to use the computer and relate it to teaching the basics of elementary mathematics. At times were felt that there was a staff planning problem – whether the mathematics tutors should teach the ICT part and relate it to teaching mathematics. The focus on learning about the computer decreased our enthusiasm to learn more about ICT because it was completely away from the realities of classroom. We need enactments and episodes that can help us to productively transfer our knowledge in schools. Schools are

implementing the ICT program. The concern is whether we can relate ICT to our classroom teaching. Elementary mathematics appear to be a viable area of application, we doubt whether our training program can help us cope with this demand.

Pamela

The teacher training program is too bulky for a two year course. There are too much of materials to be covered in such a short time of two years. Regarding elementary mathematics program, the content part was interesting but you the impression that the tutor is rushing with the program. The tutor is more concerned with completing the program than having any regard to the trainee students making sense of the content. I think we have too much to do for a preparation program in so little time. Tutors often tutors provided hand-outs to supplement lecture notes. We were not told how important and relevant hand-outs were. Some ignored hand-outs; others felt it was simply to facilitate the tutor's work. The pedagogical part of the mathematics course was very interesting. The teaching aids were really important tools in developing children's understanding of mathematical concepts. There were cases when certain teaching aids were too unrealistic, not to say far-fetched, for the simple mathematical concepts. The emphasis on concept development through activity- and inquiry-based learning seems to dominate most of lower elementary mathematics teaching. These are strong points of the elementary mathematics course. These were linked with Piaget's theories about cognitive development.

Lesson plans were important. The tutors emphasized a great on development of lesson plans. The lessons plans were designed according the tutor's norms. Instead of brainstorming us with the different ways of designing lesson plans, it was the tutor's standard approach that prevailed. Our previous knowledge of school mathematics content did not make much headway. There was no opportunity to discuss what we knew before coming to the program. The tutor's views prevailed all the time; our views were simply ignored. The tutorials discussions centered on the lectures. We could reflect on the instructions, but dissenting views were unwelcome. It appears that teacher training is a form of conditioning, where instructors' views tend to shape our knowledge.

We consider the teaching practice to be the most important part of the training program. It provided us an opportunity to try those lesson plans. They worked fine. The cooperating teacher was happy that we could try those lesson plans. It was a wonderful experience. The lesson plans

gave us a feeling that we were prepared for the work ahead. That gave us a lot more confidence to face the school work.

The course on the ICT component has been the least motivating and the most detached from the realities of our training program. The emphasis on learning about the computer, its components and resources tend to override our enthusiasm for learning to use the computer to explore the basic of elementary mathematics. ICT courses are time-tabled after the foundation courses, yet ICT courses appear to be removed from the realities of classroom application. We would have preferred a thematic analysis of the basic concepts of elementary mathematics using computer technology than addressing the content with Piaget's stages of cognitive development. The concept of Piaget's developmental stages has been over-emphasized in the simple knowledge level of pre-service student cognitive activity. Why not shift the focus from Piaget to technology?

Karen

Your question initiates me into an excursion into the past two years I followed the TCP program. The program generally covered the primary school curriculum within the two years. It was a hard task for every one: the tutors and the students. The tutors had to rush with the program content, while the students had to cope with the extent of the knowledge coverage. While they 'preach' reflection and reflective practice in teaching and learning, it was not practiced by the tutors. In the elementary mathematics education part of the course, there were no opportunities to discuss the lessons – it was one-day traffic, the lecturer dishing out the content and materials, while we were at the receiving end. We had little opportunity to discuss the content, and that was allowed only during tutorials. Was it teaching, training, conditioning, or indoctrination? It seemed we had just one avenue to follow, that of the tutor. Even the assignments were supposed to reflect the lecture's content and method. Our prior knowledge, which we thought could be useful in enhancing the lessons, was simply ignored. There was too much emphasis on activity-based learning, meaning that the child had to learn the concept by doing something related to the concept. But beyond activity based learning, there are other forms of learning, for example inquiry-based learning, exploratory approaches, learning through play and even learning through playing games. The mathematics course was too academic, theoretical, with too much focus on the development of lesson plans. It is true that lesson plans are essential and form the database from where we can always draw information and materials for our classroom work. We must not only be trained into how to transfer what we have learnt. We must learn something about what

we will teach, how we must care about it, and how we must be concerned about what we will be trying to teach. The course was too prescriptive, where the tutor's views and approaches prevailed. It was a form of conditioning where the tutors prescribed what and how we should do in classrooms. This approach was useful in helping us to develop a database or repertoire of content and pedagogy that we could transfer to classrooms.

The ICT part of the program was based on learning about the components of a computer more than learning how to use it. We would have liked to use the computer as a tool to explore concepts in elementary mathematics as part of the constructivist pedagogy. This could be a way of integrating technology into the curriculum. But we spent a good deal of time learning about the computer itself and its applications.

I would think that our tutors should support and encourage trainees to understand what was taught and not just what to transfer to the classroom. The tutor must act as a facilitator, a role model to conduct teacher training as in a 'workshop' in which trainees can be guided to explore and investigate elementary mathematics concepts

Appendix 11: Informal conversational interviews

Target audience: Senior Teacher, School Administrator, and Senior Primary Inspector (SPI)

Pseudonyms: Vijay, Devdass, Teebye

Q. 1. What mathematics curriculum do our schools need? What is your vision of a new mathematics curriculum? Can a new mathematics curriculum be developed and implemented?

Matabadul

As school administrator and having more than twenty-five years of teaching experience, I think it's time to go for a change in the elementary mathematics curriculum that would support the current reform in education. With the current drive towards a knowledge-based society, the education community is struggling to redefine school mathematics to reflect societal needs. Our school mathematics is based on an absolutist philosophy, which may be out of date and inappropriate. There is a need for a shift towards a social constructivist perspective. This shift requires a fundamental restructuring of the entire educational environment. The current 'transmission of knowledge' model based on absolutist philosophies must give way to one based on social constructivist notions of mathematics. The transition will involve changes in content, modes of instruction, and methods of assessing students' progress. Society considers the traditional school mathematics curriculum to have served its initial goals and purposes – without mentioning its negative impact on children who leave schools because they cannot 'do' mathematics. Our school mathematics must be redesigned to reflect the needs of a different social order spurred by information age. We need an elementary mathematics curriculum to prepare a new generation of learners, many of whom will, in 10-20 years time, earn their living out of working with information. Schools must realize that as the country is moving towards a 'knowledge-based economy', the needs of workers will change accordingly. The next generation of workers must learn to sensibly interpret computer generated information.

Devdass

The present curriculum is outdated. We cannot use the same curriculum to teach the next generation of students who will live in an entirely different social environment. We are living in the 21st century where the information age and the knowledge-based society are at our doorsteps.

We cannot teach children who will live in a new social order where technology will influence their life. We definitely need a new mathematics curriculum that fosters the use of technology. We should prepare children who can adapt to the transformation of social life brought about by the information age. Our vision of a new curriculum is based on two arguments: first, unlike the present curriculum which is held responsible for the high drop-outs and which nourishes private tuition, the new curriculum must provide an opportunity for all students to learn. Second, the way teaching and learning should occur must change with the new curriculum. We have seen in many classrooms, students are measuring real objects, interacting with manipulative and teaching aids, collecting and recording information. Students need to learn through conducting activities, discovering concepts, learning through play. This means that much of the same mathematics is taught, but in a different way, with a quite different method and emphasis. Computer technology and communications will have a vital role in transformation the way mathematics should be taught. Students should be allowed to move around, get involved in meaningful learning tasks, not be seated quietly at a desk with a book for six hours of the day.

The new curriculum must integrate computer technology and prepare children to face the challenges of the information age. There should be a move towards a globalized curriculum. The Internet and the Web give us unlimited access to a global curriculum. The content of elementary mathematics is changing worldwide with focus on mental arithmetic, estimation and use of calculators. The paradox here is that while computers are being introduced in schools, children are prohibited from using calculators. Word problems are still being taught the traditional way. Mathematical modeling would help ease the difficult children have with most of the word problems.

My vision of the elementary mathematics curriculum is that the present school textbooks must be carefully analyzed to eliminate those concepts which are abstract and that cause difficulties to children. Not all teachers are aware of Piaget's child development theory. The mathematics content must be restructured to make it more real and practical. It should be made learner friendly, so that no child is left out.

Ali

A new curriculum for elementary mathematics is a must for learners in the 21st century. The study of elementary mathematics is based on a philosophy that privileges the product approach to

learning mathematics. Too much emphasis is on problem solving and getting the 'correct answer', without due regard to the process part of mathematics instruction. In this respect, the MCQs (multiple choice questions) have helped to emphasize the product approach to mathematics problem solving. The present curriculum virtually ignores the process part of mathematics, which deals with formation and development of fundamental concepts. Children don't *learn* mathematics; they *do* mathematics – just to get the results. We have seen children leaving primary schools without knowing counting their monies or having any notion of measurement. The process part of mathematics education has received a very low profile in our school mathematical texts. It is high time for change.

Change and innovation come from people, communities, and other social sources. We are moving into a 'knowledge-based society.' A new social order warrants a reform of the school culture, the school curriculum and textbooks in order to respond to the demands of a society in mutation. New educational programs need to be developed and implemented to respond to the reform movement directed by the new social order looming ahead. To implement curriculum innovation successfully, several factors have to be considered. First, the characteristics of innovation, and second, how to deal with the ensuing cultural restructuring resulting from the implementation process. Curriculum materials form an integral part of school ethos, yet it is the simplest of all to change. New textbooks based on new approaches to instruction can simply replace the traditional textbooks without causing any disruption. However, the new materials have to be piloted, tried and tested to familiarize teachers with the new content and new pedagogy. The new curriculum may have a technology focus; it may well require further alterations and adjustments to be made in the classrooms. For example, new teaching aids, technology (video recordings, calculator, etc), ICT resources, software, etc. might be needed for the new curriculum. The cultural aspect is more complicated. It should reflect societal call for reform in mathematics education. Society wants school mathematics to make sense to the students. This means that the innovation proposed is significantly different from current practice of mathematics. Society wants the learning environment to change, from the traditional 'talk-and-chalk' to a technological environment. We want to see students working in groups, collecting and recording data, using calculators and computers. This culture of learning reflects a radical change from traditional learning environment with quiet students working alone.

Appendix 12

OLS Exhibit 1 – Survey problem

Introduction: In the 1950s, George Polya proposed a four-step approach to solve mathematical problems:

1. Understanding the problem. 2. Devise a plan. 3. Carry out the plan. 4. Look back.

Problem: Introducing the concept of survey problem to Standard V pupils.

Method: Polya's method. (The method serves as a natural way to introduce Venn diagrams).

Venue: Computer lab. Use MS Paint.

Technical note: It is preferred to use an approach based on children's experiences, what they know about themselves and the environment where they live and play. Some of these experiences can be useful to develop a commonsense method to introduce basic concepts in mathematics. Children are fond of pets. This exercise uses pets (dogs and cats) to introduce survey problems. .

Formulating the problem: In a classroom of 45 pupils, 25 own dogs and 20 own cats. Show this information graphically.

Understanding the problem: This involves identifying what you are trying to find (the unknowns), summarizing the information available, without imposing conditions that do not exist, and stripping the problem of unnecessary details (Wheeler & Wheeler, 1995, p. 46).

This is a natural problem enjoyed in Mauritian schools. Almost every child has a pet, yet the exercise needs to be simulated to make believe that they have one. (Children must be encouraged to formulate their own solutions.)

Devise a plan. This involves developing strategies for problem solving: making a chart or a table, drawing a picture or a diagram (in this case Venn diagrams - see Figure 1 below), guess, testing,

revising, looking for a pattern, using reasoning, or designing a model.

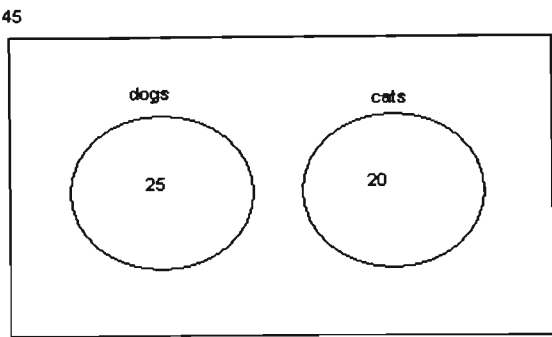


Fig. 1

Look back: 25 and 20 adds up to 45.

Procedure 2: Restating the problem. The problem is now further modified by simulating the ownership scenario.

Assume in a classroom of 45 pupils, 20 own only dogs, 15 own only cats. Show this graphically. How many pupils have no pets? We again adopt Polya's method. The result is shown (Fig. 2)

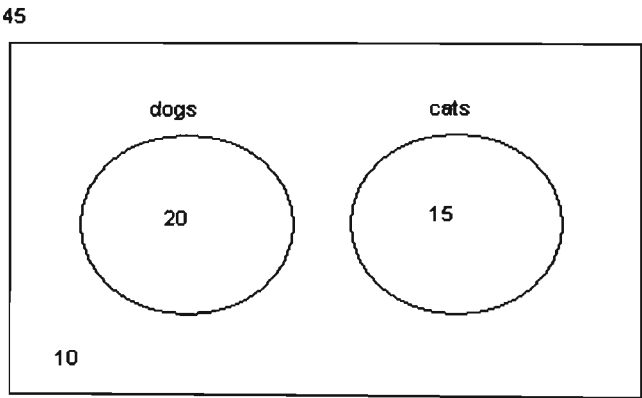


Fig. 2

Look back: $20 + 15 = 35$. And $45 - 35 = 10$, 10 pupils have no pets.

Procedure 3: The problem is now further modified by simulating the pet ownership as follows: In a classroom of 45 pupils, 20 have only dogs, 15 have only cats, while 10 have both dogs and cats. Show this info. graphically. Note: Children do experience difficulties to locate the number 10 on the Venn diagram. If allowed more time, with some class discussions, some manage to reach a solution. See Fig. 3

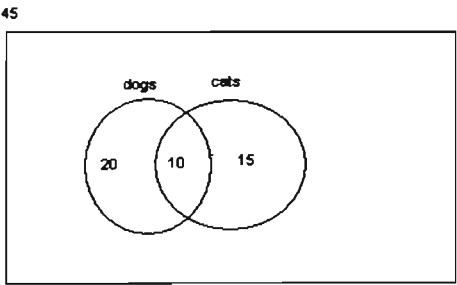


Fig. 3

Look back: $20 + 10 + 15 = 45$.

Procedure 4: Provide Fig. 4 and work backward by asking pupils to interpret the diagram.

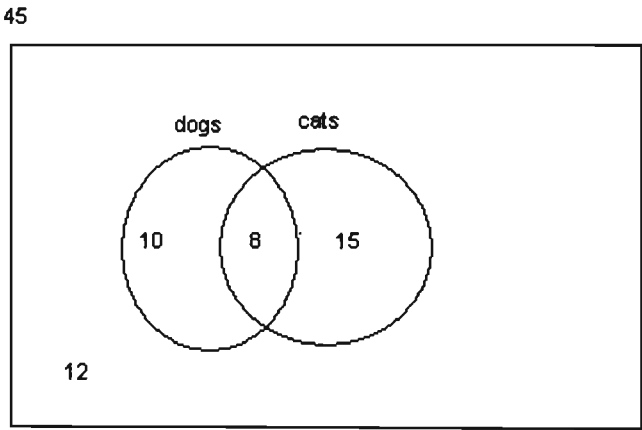


Fig. 4

Look back: $10 + 8 + 15 + 12 = 45$.

Appendix 13

OLS Exhibit 2

Concept of degrees

Historical note: *The approach in this lesson plan is drawn from Babylonians, who 2,500 years ago used a number system (and a measuring system) based on the number 60. For them, it was important to divide a circle into 6 equal parts, a constructivist strategy to understand the concept of 'the degree.'*

Aims: To give young children an opportunity to explore the concept of a 'degree.'

Venue: Computer lab.

Teaching aids: PaintBrush/CorelDraw, printing facilities, a pair of scissors.

Methods: Draw a circle using Microsoft Paint. Divide the circle into 6 equal parts (sectors). See Fig. 1.

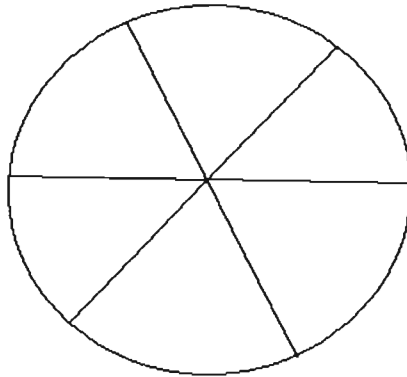


Fig. 1

Make a hard copy of the figure, and cut out one sector. The angle at the vertex makes 60 degrees. You may label the single sector '60 degrees'. See Fig

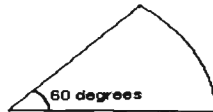
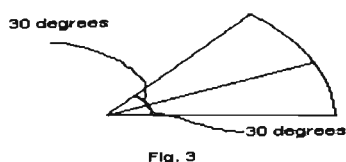


Fig. 2

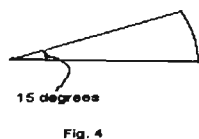
2.

2. Use the Paint magnifier to enlarge the figure by a scale factor of 2. Then divide the angle in two, as shown (Fig.3.)



3. Make a hard copy and cut off the sector with 30 degrees (any one will do). Label the sector as '30 degrees'

Fold the 30-degree sector in two and cut off a 15-degree sector. Label the sector as '15 degrees.' See Fig. 4.



4. The size of the hardcopy is too small to visualize anything less than 5 degrees. So, use Paint to enlarge the 15-degree sector by a scale factor of two. Then divide the sector into three, each having 5 degrees. You may erase two of the sectors to show the 5-degree sector. See Fig.5.



Fig. 5

5 Use Paint to magnify the 5-degree sector by a scale factor of 2. Divide the sector into 5 parts. Each part represents 'one degree' at the vertex. (This is left as an exercise for children to complete).

Appendix 14

OLS Exhibit 3 – Lesson plan on powers (exponentiation)

Objective: To give children experience related to the concept of powers.

Target group: Standard IV.

Materials: A supply of Bristol paper, pencils, rulers, scissors, compass or a drawing object (a cup or a mug.)

Method: Organize the seating in groups of 5-6 children. Each group draws a circle on Bristol paper. Cut off a paper disc, and fold it into two sectors. Show children that 1 fold of the circle gives 2 sectors (see Fig 1). Relate this to the concept of 2 'to the power of 1' gives 2, i.e. $2^1 = 2$.

Ask children to fold for a second time. Show children that 2 folds of the paper gives 4 sectors (see Fig. 2). Relate this to 2 'to the power of 2' gives 4, i.e. $2^2 = 4$.

Ask children to fold for a third time, i.e. making a third fold. Show children that 3 folds gives 8 sectors (see Fig. 3). Relate this to the concept 2 'to the power of 3' gives 8, i.e. $2^3 = 8$.

Ask children to fold for a fourth time. Children must see that 4 folds give 16 sectors (see Fig. 4). Relate this to 2 'to the power of 4' gives 16, i.e. $2^4 = 16$.

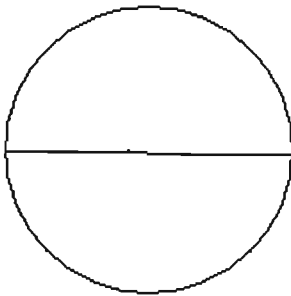


Fig. 1

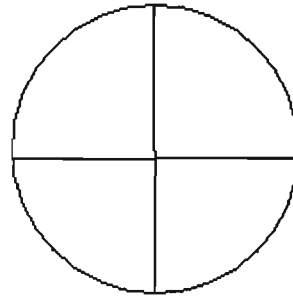


Fig. 2

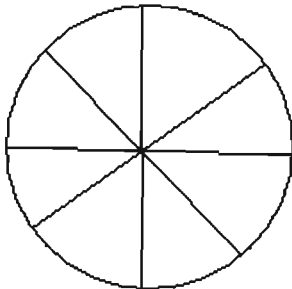


Fig. 3

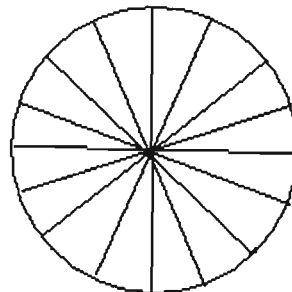


Fig. 4

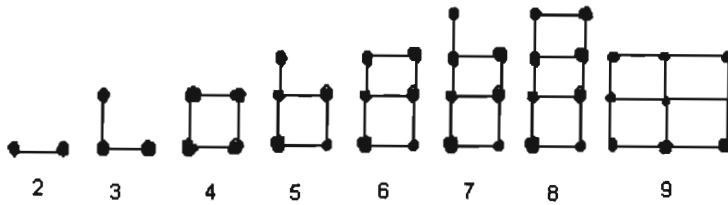
Try making a fifth fold (this may be harder, but is worth trying). Ask children to see that 5 folds give 32 sectors. Relate this to 2 'to the power of 5' gives 32, i.e. $2^5 = 32$.

Appendix 15

OLS Exhibit 4 – Prime numbers

Objective: Identifying prime numbers graphically.

Methods: Joining beads to form rectangles. Beads forming incomplete rectangles are prime numbers.



2 is a prime. 2 dots cannot form a rectangle.
3 is a prime number. 3 dots cannot form a rectangle.
4 is not a prime number, because 4 dots form a rectangle.
5 dots cannot form a rectangle. 5 is a prime number.
6 is not a prime number. 6 dots form complete rectangles.
Is 7 a prime number?
Students can be inducted into identifying prime numbers in this way.

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