The Massification of Mathematics Education and the Role of Globalisation

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Introduction

An acceleration of global trends has fundamentally altered late twentieth century life. These trends have a profound significance for all levels of education. Great possibilities now exist in mathematics education for using these trends to dramatically impact on societies, with respect to the teaching and learning of mathematics. There is a high level of expectation that information technology will play a major role in manifesting these changes. Mathematics has been more than just an important subject in education, but also a means of access to further education, mobility and professional development. The possibility now exists for the massification of mathematics education – providing access to the learning of mathematics within communities and societies who have traditionally had this severely restricted.

The argument put forward proposes that the initial indicators to emerge from an increasingly globalised world are that the gaps between the privileged and the impoverished are increasing and not closing. These trends apply to mathematics education. The challenge presented is to understand the implications of these developments. Smart decisions are needed in order to change these societal trends, particularly in the use of information technology resources

In order to illustrate certain trends and developments, experiences within the South African environment are drawn on, while attempting to link them to international trends. This decade has been particularly significant in the South African context, as it represents the first in the post-apartheid era. The consequences for the education system have been profound.

This paper will

- develop a perspective on globalisation
- consider the societal impacts of globalisation and technology over the past decade
- outline the differences in achievement between the industrialised and the developing nations
- raise some of the challenges that lie ahead.

Globalisation

Globalisation has become a term that is commonly used at all levels of society without an apparent universal interpretation. In the past ten years, globalisation has been used to describe and explain emerging trends in many aspects of contemporary social life. Some interpretations of globalisation will be raised in order to illustrate trends and effects that are taking place in education.

A common feature found in definitions of globalisation is that of a single inter-dependent world in which capital, technology, people, ideas, and cultural influences flow across borders and boundaries, rather than being contained within nations or localities. Predictions, many of which are

unfounded, are made about the future way processes will develop due to globalisation. It has been argued by some that this has led to a number of myths about the impact of globalisation (Holton, 1997).

From a theoretical view, the globalisation thesis is now well established. According to Green (1997), new global forces are transforming the world system of nation-states. National economies are eroded by the growing interdependence of world markets in capital, goods, services and information. Multinational corporations become transnational entities, relocating their operations as profit dictates, and beyond the power of national controls. Financial capital becomes equally mobile and universal. Faced with these uncontrollable world market forces, (so it is argued), governments no longer have sovereign control of monetary, fiscal and labour market policies and national economies can no longer be managed.

In addition, it is argued that cultural and political transformations are taking place under the impact of information technologies and modern communication systems. Time and space are compressed and a new global culture emerges, at once both more uniform and more particular than the national culture it replaces. New levels of political forces from outside curtail the autonomy of the nation-state by the growth of supra national, regional and world associations, institutions and corporations.

References are also made to a weakened military rationale for nationhood following the "cooling out" of international relations following the end of the Cold War and the demise of superpower rivalry.

It needs to be noted that there are several variants of globalisation theory. For example, a New Right or neo liberal form stresses the value and power of market forces and seeks to privatise the welfare state. There is also a post-Fordist version, which emphasizes the need for flexible and specialised production systems. Mention must also be made of the postmodernist contribution because of its enormous influence within academia. Post-modernism has certain close affinity with globalisation theory since most postmodernists are advocates of globalisation. They argue that the world has entered a new era of complexity driven by information technologies. They treat the nation-state as a fiction and regard large-scale collective identities like class as redundant concepts.

As far as education systems are concerned, they tend to converge around broadly similar forms under the pressure of these global imperatives. Simultaneously, economic globalisation also stresses the necessity of market competition by global capital. The battle by nation-states to improve their comparative advantage fosters a standardisation of knowledge systems in all core-industrialised nation-states. Since nation-states organise and distribute knowledge through formal education, this logic also implies a tendency for educational systems to converge (Davies and Guppy 1997).

The globalisation thesis is plausible in that many of these processes are underway. These include the growth of multinational companies, the organisation of international production, global competition, de-regulation of finance, the ideological hegemony of the market and massive technological change. It is possible to attest to the rapidly growing importance of global economic forces, and to acknowledge the significance of cultural processes and transformations in time and space.

At the same time, there are major limitations to the thesis and its application to education, which need to be highlighted. In overall terms, the globalists overstate both the extent and uniqueness of the movements they describe. They also underrate continuities. Their views have however become highly influential. Major criticisms of the globalist thesis have been mounted (Hirst and Thompson, 1996). Some of the major arguments are:

- The present highly internationalised economy is not unprecedented. In some respects, it is less open than a previous period.
- Genuinely transnational companies appear to be relatively rare. Most companies are nationally based and trade multinationally.
- Capital mobility is not producing a massive shift in investment and employment from the advanced to the developing countries.
- The world economy is far from being genuinely "global". Rather, trade and investment financial flows are concentrated in the triad of Europe, Japan and North America.
- These major economic powers have the capacity to exert powerful governance pressures over financial markets and other economic tendencies.

It seems therefore that the area of greatest exaggeration within the thesis occurs with respect to the nation-state. While its powers have declined, it is far from helpless in the face of global trends. Furthermore, national economies are far from being at the point of extinction. For example, it cannot be argued either that the US state is weak or the US economy is dependent. Much of what is attributed to the influence of global trends is better viewed as a consequence of Americanisation.

These theoretical perspectives of globalisation are raised in an attempt to capture, to some extent, a view of current ideas and scholarly writing in this area, as opposed to populist rhetoric on globalisation. What also warrants some comment is the technological determinism of the globalist approach.

Major advances, often due to technology, are reported on a regular basis in the popular press around the world, creating a perception that genuine progress is being made. Insufficient analysis, concerning the effects of globalisation, has taken place in many countries, particularly in education. Some have argued that globalisation, despite these advances, has in fact entrenched traditional patterns. For example, the argument of the globalists is that massification has eroded class barriers to entry to higher education. However, the evidence found in a number of studies demonstrates that class background remains the best predictor of the likelihood of entering higher education (Halsey, 1993; Blackburn and Jarman, 1993).

These examples are illustrations of perceptions that are often formed about achievements that are partly attributed to technology (in this case access to higher education), but they are not universally true. The danger exists that technological advances are then always seen as "good" in a populist sense. This can lead to major difficulties in certain contexts as technology can create more problems than it solves. The non-neutrality of technology is a firmly established argument (Bowers, 1988). Experiences with technology in industrialised nations, particularly in education, are often assumed to

be transferable to developing countries, and encourages a deterministic view of technology (Chandler, 1995).

Although these theoretical aspects of the contested globalisation thesis have been raised, it must also be acknowledged that a general or popular understanding of globalisation has emerged. A recent example of a major study that shows the impact of globalisation over the past 10 years is the 1999 Human Development Report (UNDP, 1999). It discusses the major characteristics of globalisation and the themes are remarkably similar.

The report argues that globalisation is not necessarily new - there were previous eras of globalisation in the early sixteenth and the late nineteenth centuries. However, this period of globalisation at the end of the twentieth century has distinctive features that are new:

- There is a shrinking of space and time as never before.
- New markets (foreign exchange and capital markets linked globally and operating 24 hours a day),
- New tools (the internet, cellular phones and global media networks),
- New actors (multinationals, World Trade Organisation and others, globally connected Non-Government Organisations) and
- New rules (multilateral agreements on trade, services and intellectual property, subject to enforcement).

The Report points out that another way of thinking about this era of globalisation is that it is a process of integration of the economy, culture, technology and governance. Although the post cold-war era of the 1990's has provided an opportunity for a better focus to be placed on global problems such as the environment, population, social development, gender and human rights issues, the real driving force has been economic market expansion. While there have been many advantages, the process has developed *unmanaged* and very *unevenly*.

Massification and Mathematics Education

The term massification is commonly used in many countries in the context of current trends in higher education. Greater parts of their populations are gaining access to higher education. The use of the term in a South African educational context is embedded in a socio-political struggle. In order to explain this significance, the South African experiences of the recent past need highlighting.

Although the history and overthrow of the apartheid regime in South Africa is well known to many, some of the underlying policies of the system are not as conspicuous. The National Party Government came to power in 1948, and (although the previous colonial oriented governments practised a more subtle form of cultural and racial separateness) set about enacting legislation of a blatantly racial form. Education was to be a pillar on which apartheid policy would be built. There is no doubt of the clear understanding the government of the time had as to the importance of education to the development of a society. There was also a full appreciation of how education is used to create barriers within a society. Verwoed, the architect of apartheid, made this clear in his infamous speech to parliament in 1956 while minister of education. While introducing the bantu education bill and describing the objects of bantu education for black african children, he used the

biblical reference - that they are to become "hewers of wood and carriers of water". He was also to make specific reference to mathematics education - "what is the use of teaching a bantu child mathematics, when it cannot use it in practice…. It is quite absurd." (Slammert, 1991).

These educational barriers within the apartheid system were remarkably successful in subjecting the vast majority of the population to second class citizenship for over 40 years. Mathematics education (or the lack thereof) was an essential feature of this policy. During the 1960's and early 1970's, black school principles were encouraged to drop mathematics entirely from the secondary school curriculum - usually under the guise that it was detracting from their success rates in the national and regional matriculation examinations. This denied thousands of black children the opportunity to pursue even their limited opportunities for further education. Mathematics is used as a filter to the majority of courses offered in higher education. This tragic legacy still haunts us today.

The rejection of this racially based social engineering system changed from a subversive struggle to open defiance with the Soweto riots of 1976. It was led by school children and erupted over a school language issue. Mathematics education was seldom raised directly, but the fuel that kept the fire burning was the hatred of the inferior education system imposed on all but the white population. The state reacted in a typical manner. Further suppression, draconian laws, states of emergency and the denial of the most basic human rights. This para-military form of law enforcement peaked in 1986 with a record number of deaths due to the unrest, while thousands of children were detained in prison cells.

Ingenious forms of opposition in the late 1980's were making the country ungovernable from within. Sanctions were beginning to show concrete results during the same period. Whether or not the developments in Eastern Europe at about the same time had a direct influence or not is unknown. The net result was an amazing period from 1990 to 1994, during which time a negotiated agreement was reached. A peaceful hand-over of power occurred from a racial minority government to a fully democratic, legitimate government following the first fully democratic election in April 1994.

These events (often referred to in South Africa as miracles) brought with them enormous expectations, none more so than in the education sector. The delivery of an improved level of education for all was one of these.

A notable educational development was the formation of the National Education Crisis (Coordinating) Committee (NECC) in 1985. This body was "founded to co-ordinate the range of struggles against the present system " (NEPI, 1993). Its slogan was "People's education for peoples' power." The NECC was preceded by the Soweto Parents Crisis Committee in October 1985 - and as the name suggests it was a response by parents and educators to the crisis precipitated by heightened unrest and school boycotts in the mid 1980's. The students had borne the brunt of the struggle against apartheid for too long. There was a general realisation a generation of black school children had forfeited even a poor education in an attempt to change the apartheid system of education. Even those that had stayed in the system and were attempting to obtain a higher education were at a severe disadvantage.

"We now have a generation of students entering tertiary institutions who have not had one year of their schooling uninterrupted by unrest, and in many cases not even one month of their entire school career has been without a break due to violence, stayaways, strikes, boycotts and the like. This generation of students grew up with the slogan 'liberation before education' ringing in their ears." (Young and Lloyd, 1991)

The NECC represented an attempt to break this mode of opposition. Children should be at school pursing their education if true liberation is to be attained. The first conference of the NECC in March 1986 resolved "to actively strive for people's education as the new form of education for all sections of our people". (Frankenstein, 1991). This represented a serious threat to the apartheid government. Despite legal restrictions placed on the organisation and its leaders being detained between 1986 and 1988, numerous gains were made. Some of the notably achievements were the establishment of education policy units at some universities in 1987 and a national education policy investigation between 1990 and 1992 (NEPI, 1993).

An important development in this mass movement was the creation of subject based commissions to investigate the implementation of new "people's curricula". First in English and History, followed closely by the People's Mathematics Commission. The importance of mathematics education, not only as an essential discipline but also as a means of educational access, was fully recognised. In addition, the traditional type of mathematics taught was questioned. People's mathematics was one of the early groupings involved in "exploring the connections between mathematics education and radical economic, political and social movements towards a just, humane society". (Frankenstein, 1991). An approach based more on constructivist, ethno-mathematical and critical-mathematical views began to emerge.

The scene was now set. Exciting new work in curriculum development was taking place. New technologies promised much in terms of computers, the Internet and communications technology. The world was becoming instantly connected as we witnessed by watching the Gulf War of 1991 on CNN. Barriers were breaking down, not only educationally but also politically, as the changes in Eastern Europe demonstrated. Was this to be the decade of real change? Would our children receive a truly different people's education? We were ready for, and expectant of, the massification of mathematics education.

What has happened over the last decade? In the South African context, a new dispensation has researched and adopted new policies, particularly in education. The People's Mathematics Commission was superseded by a new non-racial organisation AMESA (Association for Mathematics Educators in South Africa) in 1993. A more research based grouping, SAARMSE (South African Association for Research into Mathematics and Science Education), was also established. These and other developments helped to broaden the debate about a relevant and effective mathematics curriculum for South Africa (Adler, 1994). This contributed to the introducing of a revised primary and secondary mathematics curriculum in the mid 90's. Several Presidential and Ministerial commissions were instituted, including the National Commission on Higher Education (NCHE) in 1996 that articulated a new tertiary structure. The primary, secondary and tertiary curriculum is now outcomes-based in terms of policy, and full implementation is planned for 2005.

However, what has really *changed*? There have been some improvements, but the general quality of public education remains dismal. Mathematics education at the primary and secondary level is as far from the massification ideal as ever. Indeed, while private education at all levels (pre-primary to tertiary) is flourishing, the public education sector remains in a crisis mode. In a recent statement, the newly appointed South African Minister of Education states that "we have created a set of policies and laws in education and training that are at least equal to the best in the world." Yet, at the level of implementation the educational system is problematic. The Minister goes on to state: "Large parts of our system are seriously dysfunctional. It will not be an exaggeration to say that there is a crisis at each level of the system. I will select the worst and most troubling features of our education and training system for special mention: the massive inequalities in access and facilities, the serious state of morale of the teaching force, failures in governance and management, and the poor quality of learning in much of the system (DoE, 1999).

During this decade, South Africa has moved from a state of policy formulation, mostly in the early 90's, to a mode of implementation, in the later 90's. Most developments in mathematics education have met with limited success. There is a general level of disappointment and frustration. Some general global trends over this period, that can also be identified locally, need to be considered in order to assist in accounting for this position.

Globalisation without a Human Face

Returning to the 1999 United Nations Human Development Report, there are clear indications of the potential positive power that globalisation has in order to bring social and economic benefits to societies. It also points out the many negative effects that globalisation has had on human development and argues that the challenge is to achieve globalisation "with a human face" (UNDP, 1999). It cautions that globalisation is too important to be left as unmanaged as it is at present, because it has the capacity to do "extraordinary harm as well as good."

The first Human Development Report, published in 1990 opens with the lines:

> "The real wealth of a nation is its people. And the purpose of development is to create an enabling environment for people to enjoy long, healthy and creative lives. This simple but powerful truth is too often forgotten in the pursuit of material and financial wealth." (UNDP p1, 1999.)

Ten years later in seems that we are far from accepting this truth. A dominant characteristic of this decade has been the globalised pursuit of material and financial wealth. The overall effect has been significant gains in certain areas, but the real cause for concern is the widening of the gap between the *haves* and the *have-nots*.

Some global achievements between 1990 and 1997 that are worthy of note are:

- In 1997, 84 countries enjoyed a life expectancy at birth of more than 70 years, up from 55 countries in 1990. During the same period, the infant mortality rate was reduced from 76 per live 1000 births to 58.

- Between 1990 and 1997 the adult literacy rate rose from 64% to 76% and the gross primary and secondary enrolment ratio increased from 74% to 81%.
- During 1990-97 the net secondary enrolment for girls increased from 36% to 61% and the economic activity rate for women rose from 34% to nearly 40%.
- Despite rapid population growth, food production per capita increased by nearly 25% and the real per capita GDP increased at an average annual rate of more than 1%.

While these global achievements are impressive, they hide some of the unevenness that has occurred. On closer examination of these figures, the inequalities are stark. Some of the differences in achievement are:

- By the late 1990's, 20% of the worlds' people from the highest income countries had 86% of world GDP (gross domestic product) - the bottom 20% had 1%. The income gap between these two groups increased from 60 to 1 in 1990 to 71 to 1 in 1997.
- Eighty countries have per capita incomes that are lower than they were a decade or more ago. Most of these countries come from Sub-Saharan Africa, Eastern Europe and the Commonwealth of Independent States (CIS).
- The net worth of the world's 200 richest people increased from $440 billion in 1994 to more than $1 trillion dollars in 1998. Another illustration of this concentration of individual wealth is that the assets of the three richest people in 1998 were more than the combined GNP (gross national product) of the 48 least developed countries.

While the argument about convergence and globalisation has been strongly made (Davies and Guppy, 1997), the past decade has shown increasing concentrations of income, resources and wealth among only some people, corporations and countries. This shows a selective rather than universal convergence in the resources available for basic social needs like health, housing and food.

In educational terms, the disparities are as stark as ever. The industrialised countries have a significant advantage in participation rates. This is particularly the case when it comes to the most disadvantaged group of countries - those in Sub-Saharan Africa. The primary enrolment ratio for industrialised countries is effectively 100% (99.9). For Sub-Saharan Africa, it is 56.2%. The secondary enrolment ratios show even bigger disparities: 96.2% as against 41.4%. The percentage of children not reaching grade 5 is 0% for the industrialised countries, while more than 3 out of 10 (34%) children do not reach grade 5 in Sub-Saharan Africa. (UNDP, 1999 p.176.)

These figures are given in order to illustrate some disturbing trends that have occurred during the first decade of globalisation. The reversal of these trends is going to constitute one of the major societal challenges of the next decade.

The advances made in IT in the early 90's in terms of cellular phone technology and the Internet was a cause for optimism, particularly in terms of the educational possibilities for developing countries with large rural, isolated populations. The rapid rate of development of these technologies is marked by the rate at which their use is growing - it took radio 38 years before there were 50 million users, personal computers 16 years and television 13 years. It has taken only 4 years for the Internet to

achieve 50 million users. Nevertheless, at the end of the decade, there is a polarisation between the connected and the isolated. In 1998, the Internet posed serious problems of access and exclusion:

- South Asia, with 23% of world population, has less than 1% of Internet users. By contrast, North America with less than 5% of world population has more than 50% of the users.
- The richest 20% have a 93.3% share of the Internet, the poorest 20% about 0.2%.
- 30% of Internet users have at least one university degree.
- To purchase a computer would cost the average Bangladeshi more than eight years' income, the average American, just one month's wage.
- Men dominate on the Internet. In 1998 and 1999 women accounted for 38% of users in the United States, 25% in Brazil, 17% in Japan and South Africa, 16% in Russia and 4% in the Arab States.
- Youth also dominates the Internet - the average age of users in China and the United Kingdom is under 30.
- English prevails in almost 80% of all Websites, yet less than one in 10 people worldwide speaks English.

These trends are reflected in the South African context. The expectations held by some that we, as a country, were going to be able to leapfrog in communications technology, has not come to fruition for the vast majority of the population.

- The cellular phone industry has developed dramatically over a six-year period. However, it is only the upper-income class that has substantial access.
- Although South Africa had 3.82 Internet hosts per 1000 people in 1998 (which places it in 36th place in global rankings), about 75% of schools have no telephone line (UNDP, 1999, p55, p59).
- South Africa accounted for 95% of all Internet hosts in Africa in 1988 (Hall, 1998, p2), yet the average South African user has an income 7 times the national average. (UNDP, 1999, p62)

These unequal distributions are also reflected in the uneven impact on the education system and the anticipated delivery of people's mathematics. A lack of resources, both human and financial, has impacted on concrete developments in mathematics education. Improvements, particularly concerning access to resources, have been mostly confined to those that are already well resourced. There are circumstances that are particular to the post-apartheid South African education system that impose other pressures. Nevertheless, global trends have been experienced locally. The gaps have widened rather than narrowed.

What lessons can be learnt?

An evenly distributed improvement in mathematics education on a global basis has not occurred. Improved access and higher participation rates have generally occurred in countries that have experienced material and financial benefits from globalisation. This has meant that the education gap has widening rather than closed. In terms of the free-market, global economy that has emerged in the 90's, very little will happen to close the gap between the rich and poor, the haves and havenots, the mathematically advantaged and disadvantaged.

The impressive developments in mathematics computer packages and applications in the 1990's have had benefits - but mostly in prestigious engineering and science faculties and well resourced mathematics departments in the secondary and tertiary sector. The belief that these gaps would start to close in a globalised, connected world has remained just that - a belief. Developments in communications and information technology do not necessarily imply that these resources are available to all. It is the well resourced that usually benefit.

A less obvious lesson, in need of greater attention, is that when technology and resources are made available, they do not necessarily have the intended or anticipated impact to improve the learning environment. In a South African study on introducing resources into the learning environment, as part of a further education programme for mathematics teachers, it was found that their use by teachers is "always partial, uneven, personal and contextual". (Adler, 1999.) In order to introduce equity to our education system, equalising the allocation of resources is often believed to be a solution. This study shows that these "simplistic notions of equity through resource distribution in mathematics education" need to be challenged.

Thus, the provision of these resources and technologies does not guarantee pedagogical change or improvement. We need to see the value in and focus on human development if progress is to be made: "more resources does not necessarily equate with better practice" (ibid.). Situations have to be contextualised before decisions about the use of resources and technology to enhance mathematics education are made. Developing countries must not become technology dumping grounds as a panacea to solve their educational problems, and ensure markets for the exporters of technology.

A factor that has not been dealt with at any length is that of curriculum reform, which can often include changes in access to resources and technology. Inevitably, the central players are the teachers; a fact often overlooked in learner centered policies. They need to be involved in, and empowered by, any of these reforms. Early experience with the outcomes based curriculum in South Africa is that when the old is jettisoned too quickly in favour of the new, there is general resistance or confusion. Incremental change is necessary and an essential feature throughout the process is the empowerment of the teachers. Technological solutions that exclude or marginalise educators are doomed to fail.

At this point, I want to turn to some personal experiences with technology in mathematics education over a 20-year period. Although I am drawing on these localised experiences, there are features that need to be highlighted as we move further into an information society that is dependent on new technology. Although issues concerning the non-neutrality of technology and technological determinism are relevant here, the focus is rather on decision making frameworks in relation to technology in mathematics education (and education in general). This approach has been influenced by work I have done in two studies. A report on libraries and information technology for our National Commission on Higher Education (NCHE, 1996), and a technology enhanced learning investigation for the South African Department of Education (TELI, 1996). The essence of the approach is to develop an understanding of the educational objectives and outcomes of the activity

as a starting point. Smart decisions about the role of technology are then made as part of a wider process in order to attain the required outcomes.

I have had extensive experience in teaching mathematics service courses at university level. These are courses given to non-mathematicians, who need a level of mathematics for their major discipline. This includes students doing subjects like medicine, finance, economics, architecture and engineering. Very often, this entails large numbers of students, with a low level of motivation and a poor achievement record in mathematics; and invariably academic staff who are unenthusiastic about teaching these courses. A technological solution that we have explored in order to alleviate some of these difficulties is the use of television. There have been three major projects. The first was a series of televised lectures as far back as 1978 that covered a full year course in an attempt to capture the expert and experienced lecturer on tape so that all students could benefit. The series was also motivated by an adverse student staff ratio. A second series was produced in 1981 after research had been carried out on a more effective format (Young, 1986). This series was a high-tech version that was also very costly. A third series was produced in 1987 at very low cost with no special effects. This last series is still in use by students as a back-up resource.

There are some important lessons here. Initially, the naï ve assumption was that we could replace the lecturer. Although in some cases this was partly true, students still wanted the live experience. No matter how good the programmes were, a real experience was preferred as long as the presentation was reasonable. Inexpensive productions of live presentations are still used. Pressure from staff dealing with mathematically disadvantaged student needs, encouraged us to continue with this resource. The existence of this content-based resource has permitted other interventions in the learning environments that have a greater focus on the individual learner.

One of these was a peer group learning experience. Without going into the detail, student performance improved despite possessing poor levels of the required learning skills. These skills include pre-reading abilities in mathematics, self-motivation and positive experiences of structured group learning. In addition, staff in adjusting to a new learning environment experienced some difficulties. The creation of this new environment was made possible as the necessary back-up resources existed. Content-based lectures were available in the library on videotape, comprehensive lecture outlines were linked to reading references, and clear course objectives existed. Despite the success of this approach, it has not been possible to sustain. Although the reasons for this are manifold, they centre on the availability of human resources and the broader learning culture of the institution.

Another example is the continuous feedback that students receive, despite an adverse staff student ratio. This involves regular testing via computer marked multiple choice questions coupled with full written responses. Without going into an explanation of the pedagogy, another important aspect emerged. This type of approach has been used elsewhere in many forms, particularly with the advent of networked PC's. Very similar outcomes where achieved without student access to PC's, by using flexible scheduling and a normal testing environment. The technology used to generate and mark the questions is now very dated equipment that runs off a 286 machine. Although the equipment is 10 years old and runs under DOS, it is still used. A similar outcome would be obtained

in a computer laboratory at more than 100 times the cost. The small additional benefits that may result could never justify the enormous financial commitment.

The temptation to request large resources like computer laboratories for students is understandable. Topics we teach in financial mathematics in these courses that require numerical techniques are particularly suited to a didactical approach that uses a PC laboratory. Due to the economic constraints experienced by many of our students, carefully selected calculators have been used rather than PC's, and have been prescribed equipment for these courses since 1984. This has been at a fraction of the price of computers and virtually the same objectives have been achieved.

The salient point is that cheaper technological solutions can often be as effective as expensive, leading edge technology. These experiences have shown that, although the technology has aged it still does almost as well as equipment that is more expensive. Cost effectiveness and the use of technology are critical issues for developing countries. If cost effectiveness is not optimised, sustainability will not be achieved. A common feature of these examples is that the use of the technology has been sustainable over a long period.

What Needs to be Done?

As the new millennium approaches, what can be done to reverse some of the negative trends that globalisation and the free market economy have induced? These concerns are no doubt of greater concern to developing countries than for the industrialised nations, although serious disparities exist even within the most advanced economies.

Questions regarding the *impact* of these developments on mathematics education and the massification of mathematics learning must be addressed. The theoretical developments in mathematics education during this decade have opened exciting possibilities. Yet, the constraints placed on the implementation of these ideas must be faced. The influences of resources and technological developments in a globalised world have to be factored into any planning of curriculum change and development.

Some international arguments have been made concerning the solutions to these problems. They revolve around

- reducing the threats of global financial volatility and all their human cost by introducing greater governance of globalisation
- enhancing and developing technologies that contribute to human development and eradicate poverty
- reversing the marginalisition of poor countries and improving structures for regional solidarity and cooperation

Without some progress in these areas, changes in global trends will not occur.

On a national basis, all countries need to rethink their social policies, particularly in the areas of redistribution, safety nets, social services and universal education. Progress in these areas is fundamental to developing countries before globalisation and technology can have any significant

impact. "Even for the newest and most advanced technologies, the most basic and long-standing policy lies at the heart of the solution: investment in education." (UNDP, 1999, p62.)

In conclusion, as was stated at the outset, it is difficult to extricate general societal challenges from those that apply more specifically to mathematics education. They are intertwined. Within this complexity, three important components, that are essential to the massification of people's mathematics, emerge. The first is the focus on the development of *people* and the emphasis here is on mathematics educators. Secondly, any developments (which include curriculum reform and the use of technology) must be evolved within particular *contexts*. Finally, the question of *sustainability* must be addressed. In South Africa, the euphoria and excitement of the early nineties have been difficult to sustain during the process of implementation.

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