TEACHERS' PERCEPTIONS ON TEACHING MATHEMATICS IN THE 21ST CENTURY

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Abstract

This study seeks to explore teachers' perceptions on the teaching of mathematics in the 21st century. Using the context of a high failure rate in mathematics, the study followed a qualitative research method to collect and analyse data. Face-to-face interviews were conducted with purposively selected teachers teaching mathematics in Grades 10, 11 and 12. Qualitative data was analysed thematically and supported with literature. The findings indicate that teachers face challenges in planning mathematics classes due to factors such as limited resources, infrastructure and overcrowding. In this study we argue that effective teaching and learning is extremely difficult if not impossible in poor resourced and disorganised classrooms. If the challenges can be addressed, the high failure rate will be improved.

Key words: Mathematics; 21st century; digital kids; digital learning; classroom planning.

1.1 INTRODUCTION

South African education system is in a dilemma of undergoing some remarkable transformation. There is a plethora of education policy documents, plans, strategies and interventions. For example, the outcomes-based education (OBE) system which had been introduced in the late 1990s has come under critical scrutiny. In 2009, the Revised National Curriculum Statement (RNCS) was revised after being reviewed by a Ministerial Committee, and a new curriculum document, the Curriculum and Assessment Policy (CAPS), came into effect in January 2011. This transformation poses major challenges to education whereby teachers have to apply new approaches to teaching. One of the challenges is that of teaching with technology (White paper on e-Education 2003). Though the South African White paper on e-Education set a demand, it is not so clear whether teachers in the system are well equipped with the necessary knowledge and skills to perform this task. Learners in the 21st century are digital, and their learning is digital. In light of the above information, Shelly, G., Gunter & Gunter, R. (2012)Shelly refer to the 21st century learners as digital students or digital kids. The authors define digital kids as kids who are hyper communicators, who use multiple tools to communicate; multitasks who do several things at once with ease; and goal oriented as they pursue multiple goals at the same time. Some authors (e.g. Tapscott, 1998) refer to these learners as the Net generation. The most useful designation Prensky (2001) found suitable for them is digital natives. The author describes this generation according to the type of language and activities they do, and further states:

> "Our students today are all "native speakers" of the digital language of computers, video games and the Internet. Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to "serious work" (Prensky, 2001:2).

In light of the above definitions and for the purpose of this study, the terms 'digital kids' and the 'Net generation' will be used interchangeably in this study. In comparison to the digital kids, it is assumed that most of the teachers teaching this generation are not fit to teach in this digital context. This is generally based on the approaches and strategies teachers used. In essence, these methodologies do not suit the Net generation. Prensky (2001) refers to these teachers as digital immigrants because they have very little appreciation for the new skills that the natives have acquired and perfected through interaction and practice. These skills as Prensky (2001) states are almost totally foreign to the immigrants, who then choose to teach slowly, step-by-step, one thing at a time, individually, and above all, seriously. According to Prensky (2001) digital immigrants do not believe their students are multi-taskers, that is, they can: learn successfully while watching TV or listening to music, and think learning cannot (or should not) be fun. This results from the fact that the digital immigrants themselves cannot multitask because they did not practice these skills constantly for all of their formative years.

Based on the given information, it is a great challenge to both teachers and learners to interact effectively in the teaching and learning environment, especially in mathematics. In South Africa, learner performance in mathematics is gradually decreasing, as compared with learners internationally including those in other African countries. The World economic Forum (2013) ranked South Africa 62nd out of 62 countries on measuring the quality of its Mathematics and Science Education. South African learners often score lowest (Stauss & Burger 2000; HSRC 2004) in mathematics. In support of this view, statistics (Mail & Guardian, 2 Jan 2013) for the past three years indicate that most learners who wrote matric examination in South Africa have been performing badly in mathematics (see table 2 for the results). In addition, the national Department of Education's systematic evaluations of Grade 6 in 2005 indicate that learners obtained a national mean score of 27 per cent in mathematics (DoE 2005). Six years later, the results of the 2012 Annual National Assessments show some improvement in the Foundation Phase, but alarmingly poor results in the Intermediate and the Senior Phases (M&G 2012).

Table 2: Matric pass rate for the past three years (adapted from Mail & Guardian, 2 Jan 2013)

Year	**2010**	**2011**	**2012**
Pass %	47	46.3	54

Despite the plethora of education policy documents, plans, strategies and interventions, it is clear that the majority of South African learners are far from mastering the basic and minimum competencies required of them by the curriculum (Sayed & Motala 2012). Yet, Mastropieri and Scruggs (2000) see mathematics as the leading subject and key to all the disciplines and they describe it as follows:

> "Mathematics is the key to opportunity. No longer just the language of science, mathematics now contributes in direct and fundamental ways to business, finance, health and defence; for students it opens doors to careers, for citizens it enables informed decisions, for nations it provides knowledge to compete in a technological economy" (p. 459).

Mastropieri and Scruggs (2000) further argue that students need to gain proficiency in mathematics to fully participate in society. For this to occur, teachers must be fluent in a variety of teaching techniques that will allow students with diverse learning needs to meet their greatest potential in mathematics. In the same note, Nichlieli, Herbst, & González, (2009) compare a teaching environment to a performance. They emphasise that teachers are like the directors, their students the actors, and the classroom the stage; lessons are the play, and the students and teachers work together to achieve a performance faithful to the script, hence teachers and learners are joined stakeholders in classroom results. This would mean that teachers expect at some points to be able to claim that they had taught the particular skill, likewise, students hope to claim that skill at some point before the course is over. All the parties do this by interacting and with the help of the tools they engage with in mathematics classrooms (Nichlieli et al. 2009).

The central purpose of this study is to explore the perceptions of teachers on teaching mathematics in the 21st century. In this paper we argue that the teaching of mathematics in the 21st century is a challenge to teachers because most of them are digital immigrants whereas the learners they teach are digital natives. However, teachers are trying to cope with this current situation; the majority of learners do not show good performance in mathematics.

There is limited research done on the perceptions of teachers on the teaching of mathematics in the 21st century, especially in the South African education context. Today's learners have changed radically; they are no longer the people the education system was designed to teach. Teachers still assume that learners are the same as they have always been, and that the same methods that worked for the teachers when they were students will work for their students now. It is not so clear to teachers whether the learners should learn the old ways, or whether teachers should learn the new? It is therefore believed that if teachers can reconsider both methodology and content, the challenges experienced in teaching mathematics will be minimised. This study begins by describing digital learning and explaining how the mathematics classroom in the 21st century should look like.

1.2 DIGITAL LEARNING

The 21st century education as mentioned in this study is based on the fact that a technological revolution has taken place in this millennium. This particular revolution has a huge impact in the society. Education in the 21st century is affected in a sense that "learners need to be able to use new and emerging technology to learn the 21st century skills and knowledge; these skills are known as information literacy, media literacy, information communication and technology literacy" (Shelly et.al, 2012). To be precise, Shelly et al (2012) give some definitions to these skills as follows: information literacy is described as knowing how to find, analyse, and use information. For media literacy, they describe it as the ability to create, develop, and successfully communicate information in all forms.

According to Shelly et al (2012) learners in the 21st century "have a virtual world at their fingertips, with all its pitfalls and promises; in fact many people believe that today's youths spend more hours, in front of computer screens, watching and creating video, listening to music and playing computer and video games; they speak digitally, therefore many have called them a digital generation," (p. 15). These learners are technologically advanced and would not compromise learning mathematics content in the traditional way because traditional approaches to learning are linear, dating back to the book as a learning tool which is usually read from the beginning to the end (Tapscott 1998). However, the teaching and learning of mathematics in the 21st century is not only based on paper and pencil, chalk and board activity, it is also based on a range of technological tools such as scientific/graphic calculators and computer programmes.

1.3 MATHEMATICS CLASSROOM PLANNING IN THE 21ST CENTURY

A concern to be raised in this context is how teachers plan the teaching and learning environments that will cater for effective digital teaching and learning. To address this concern, organised classrooms with necessary, relevant and enough resources remains a key to successful teaching and learning. It has been averred that planning enables the teacher to avoid inappropriate learner behaviour by organising the classroom and material so that the physical environment is conducive to learning (Van der Horst & McDonald 1997). To enable the digital kids to cope and adapt with the learning environment, it is imperative to focus on the introduction of all technologically inclined materials, for example planning computer aided lessons, using videos, overhead projectors and i-box. For this matter, Fosnot (2003) argues that teachers have to turn the mathematics classrooms into workshops. To accommodate digital kids, the mathematics instruction must be changed from "a chalk and black board mentality to a greater use of technology in every level" (Harvey and Osborne (1991: 79).

Regarding learning in the digital era, it has been motivated that kids do not want optimised, pre-digested information; they want to learn by doing where they synthesise their own understanding usually based on trying things out (Brown, 2002). According to Furner et al (2005) with the diverse learners, the use of multimodal approach that incorporate multiple intelligences cater for students' short attention spans, as they are not expected to merely sit still and learn the material. Furner et al (2005) further emphasised that students can learn mathematics through acting out maths problems, for instance, go on internet field trips with a typically able peer and manipulate tangible objects that help them to concretize abstract concepts. In order to help learners to move from the abstract to the concrete, certain topics would need technology to unfold. For example, teachers need to teach 'calculus' in a way that facilitates complex and sophisticated numerical computation in the age of computers (Demana et al. 1991).

1.4 THEORETICAL FRAMEWORK

Taking account of the many claims in published research that young people are "growing up digital" (Tapscott, 1998), accentuate an urgent need to shift the goal for learners from acquiring facts and content knowledge to becoming more digitally proficient, critical evaluators, creative producers and ethical users of new technologies. With this shift, the focus for learning becomes not so much on the subject content selected, but on how to develop the learner's cognitive, metacognitive, performative and transformative capabilities in line with the subject content. Tapscott (1998) highlights six shifts that educators can evaluate themselves when teaching in the digital class. These include a shift: from teacher-centred to learner-centred education; from absorbing material to learning how to navigate and how to learn; from school to life-long learning; from one size fits all to customised learning; from learning as torture to learning as fun; and from the teacher as transmitter to the teacher as facilitator.

A motivation has been given that the question of instruments in mathematical activity is without doubt a crucial question today (Guinn, Ruthvent, & Trouche, 2005). The authors further asserted that the domain of calculation is perceptible because a narrow vision of it may lead people to think that it is no longer necessary to learn because instruments can today take charge of all work. Based on this view, learners would not prefer thinking critically, when a calculator is there. They would be introduced to computer programmes, but the computer cannot give them (learners) answers during examinations. Orientation to technology should be complemented by mental engagement in problem solving, that is to say that an instrumented, intelligent, efficient and controlled mathematical practice requires significant mathematical knowledge (Guin et al 2005).

In an era where developments are taking place, where technology is vastly influencing every area, Ramagnano (1994) poses questions regarding the teaching and learning of mathematics. These are as follows: (1) why is it difficult for learners to cope with mathematics? (2) Why would students react (fail, have a negative attitude) the way they do? (3) What is the problem with teacher approach to the extent that it poses difficulties in learning mathematics? The author also considered facts like learner and teacher differences in view of mathematics, the teacher, the class discussions and assessment.

The incorporation of technology could assist in learner pedagogic development. It has been stated that desks, textbooks, blackboard, chalk and an answer book are no longer all that need to be provided (Watson 1976). The author further motivated that mathematics teaching now involves much more practical activities. However, in this digital era practical activities pertains to computers, calculators, i-box, projector, permission to use cell phone internet in class and many more technological tools. Many schools have inadequate facilities; therefore these considerations should be borne in mind when school buildings are planned or modified. Teachers are challenged to teach in new approaches, that is, to move from old to new systems in order to accommodate the digital kids. As much as learners are challenged to be critical thinkers even when technology has been much of a focal point to them, they rely much on the usage of tools like computers and calculators to have a quick way to problem solving. Teachers on the other hand are also challenged to think critically of the strategies and teaching approaches they will employ when delivering the content. In light of this information, it has been stated that application of technology in mathematics teaching may leave teachers cautious when asked to begin teaching mathematics in a new way, and therefore anxieties and threats such as (1) perceptions of undermined status, especially if students appear to be more competent with technology; (2) fear of losing control in the classroom as activities become more diverse; and (3) concern about "peer pressure" especially from senior colleagues if a class does not appear to run well may be perceived (Fosnot 2003).

Teachers have to develop an element of confidence in order to teach effectively in the digital era. For this matter, the effect of technology on teacher confidence has been divided into three categories (Berry et al 1997): (1) Teachers who embrace technology wholeheartedly, finding innovative of breathing new life into tired old syllabi so that mathematics becomes accessible and interesting to a large population of learners, and these teachers were named "flag wavers"; (2) teachers who are opposed to any use of technology for teaching mathematics, often extremely talented mathematicians themselves and may well believe that using technology in some way compromises the integrity of mathematics as a purely rational process which needs human mind, a piece of paper and a pencil in order to be communicated, and these teachers were named the "philosophers"; and (3) in between flag wavers and philosophers are those who could but, as yet, do not use technology to teach mathematics, they are generally responsible and diligent people

who put the teaching of mathematics and the needs of their students at the top of their list of professional priorities, and these teachers were named "general practitioners".

1.5 RESEARCH METHODS

The data reported in this paper are derived from a qualitative research design. The total sample for the purpose of this study comprised eleven participants. Eleven teachers teaching mathematics in the senior secondary schools (Grade 10 – 12) were purposively selected to participate in the semi-structured interviews. Ethical considerations with regard to voluntary participation, anonymity and confidentiality were adhered to during data collection. Permission to conduct research in the schools was granted by the Gauteng Department of Education in South Africa. Permission was sought from teachers who were interviewed. Data was analysed qualitatively in terms of the themes and categories specified for the study, namely classroom planning and organisation; learner performance; and teacher and learner support. Although the findings of the study cannot be generalised owing to the small samples that were used, they provide rich information on teachers' perception on teaching mathematics in the 21st century.

1.6 FINDINGS

For the purpose of this study, the authors have chosen to select and highlight the specific themes, concerns and challenges largely voiced by participants throughout the interviews. Findings are organised thematically and coded according to classroom organisation, learner performance, and teaching and learning support.

Classroom organisation

Teachers are still experiencing challenges with regard to classroom organisation. Due to overcrowded classes it is difficult for teachers to organise their classrooms to be conducive to learning. Efficient planning, facilitation and implementation of learning experience become a nightmare. Overcrowding also leads to insufficient resources and infrastructure. Resources such as furniture for both teachers and learners were highlighted to be the most impeding factor to teaching and learning. For example learners have to squeeze themselves around few available furniture such as tables and they also engage themselves in unnecessary fights, fighting for the chairs. In this regard, learners come up with a principle of 'grab and go'; meaning that the one who grabs the chair first will have it for the day.

Infrastructure was also pointed as the major obstacle to the effective teaching of mathematics. This refers to shortage of classrooms that can be assigned specifically for mathematics. In most public schools classrooms are normally used for all subjects, and this makes it difficult for other subject teachers. One of the participants in this study Kamogelo (*pseudo name*) raised a concern

regarding shortage of space (infrastructure) and states: "*it is not possible to display on walls because all teachers use the same class for teaching...the display cannot stay longer to create space for other subjects.*"

Teaching with posters play an important role to learning as learners with limited resources such as computers can still learn from the posters. Thus, limited space impact negatively to learners, as they will be given little time to refer and learn concepts from the posters. Though posters are seen as important to learning, learners sometimes do not see them as important; they even forget that they exist. One of the participants in this study raised a concern about the usage of posters, and explains: "*we should always refer to materials pasted on walls when teaching so that learners will also see the importance of the materials and hence use them fruitfully...most learners see them as classroom decorations*".

It seems most of the learners are not observant enough and this leaves them to be ignorant. Another participant add on the issue of posters and states: "*learners are ignorant, you can ask them about something on the poster pasted on the wall, but they will simply say they do not know*."

Learner performance

On the issue of learner performance participants highlighted the point of varied performances. It shows that other learners perform better while others struggle with the mathematics content. One of the participants in these interviews substantiates this fact and explains: "*all learners can do mathematics, but they do not put effort in studying equally*".

This may suggest two ability groups in the learning of mathematics. From the interviews it was indicated that some learners spend hours practising mathematics, discussing their challenges with teachers, while others do not even bother themselves. One of the participants explains this matter in this way "*the uniqueness of learners is the main reason that learners cannot achieve, other learners are highly gifted ...they cope easily, while others are not gifted and mathematics seems to be challenging to them.*"

The uniqueness referred to in this regard pertains to learner interests, capabilities and learner individual styles of learning. Learners' perceptions are not the same; therefore their attitudes will also differ. Some learners may display a positive attitude towards mathematics, the teacher and the environment, while others may show a negative attitude, either towards the teacher, or the content with a claim that the subject is difficult and challenging to them. Learners may also shoe an attitude towards the environment which is unfavourable to them, for example resources might be lacking, or not up to the standard of their era, that is, the resources and material tedious and unexciting. These attitudes might also affect learning whereby learners will take everything as difficult and lacks a sense of solving some common problems. Participants saw the importance

of common understanding in the learning of mathematics and one of them states: "*learners cannot incorporate common sense in mathematics by linking mathematics and real life situations, by common sense I mean for example... when bathing you need a certain amount of water...you have to automatically use a certain scale in the brain ... I found that my learners could not tell me when the bath will have enough water for them to go in without losing a drop...*".

Teacher and learner support

Support is crucial for both teachers and learners in any educational institutions. Support system should be from all the stakeholders in the particular organisation. These may include school management teams, school governing bodies, parents and the department of education. Participants show a need for the following support: "*we must be given funds for teacher and learner support material, because teacher and learner material hinders the progress of teaching and learning*".

Participants emphasised the fact that the provision of resources in schools have been delayed, and principals, governing bodies and the department of education were parties to be held responsible. They further expressed a common feeling regarding their empowerment. They explain that training and empowerment workshops are not regular, especially on different topics in school mathematics. In addition to these feelings, one of the participants expressed his feelings in this way: "*I would like to study further, but I never get motivation from my work, if we can be given bursaries to study further, under-qualified teachers would be a story of the past."*

1.7 DISCUSSION OF RESULTS

The summary of findings was done based on the following themes: classroom planning, learner performance, as well as teacher and learner support. For the purpose of this study, these themes are discussed under this section and relevant literature was consulted to contextualise the issues explored. Mathematics classroom became difficult for teachers to organise in a poor resourced context. Participants frequently mentioned posters and furniture as the necessities for efficient mathematics planning, facilitation and implementation. There is a gap between digital learners and teachers who are not technologically oriented, and for this reason teachers are challenged with unavailability of technological tools that will assist them in planning their lessons. In essence, classroom settings should be restructured to suit the needs of a learner in a modern technological world. This is in line with Fosnot (2003) who argues that teachers have to turn mathematics classrooms into workshops. In technological terms a workshop is a space of teaching and learning well equipped with different types of learning tools and materials for that specific subject. Classroom organisation in the 21st century needs to be digital, and focus on the needs of digital kids who are diverse learners. Furner et al (2005) see diverse learners as those who have short concentration spans. To cater for these learners Furner et al (2005) suggest the

use of multimodal approach that incorporates multiple intelligences that will cater for these learners.

Learner performance in mathematics was another area of discussion. For the fact that learners referred to in this study are digital, it is a call for teachers to use multiple teaching approaches during instruction in order to accommodate all learners. In support of this view, Harvey and Osborne (1991) argue that 'to accommodate the digital kids, the mathematics instruction must be changed from traditional mentality to a greater use of technology in every level. It is important for schools to introduce technology (both hardware and software) for the teaching and learning of mathematics. Teaching and learning with technology could help in developing learners' interest and could also make mathematics "relevant, instant, useful and fun" (Shelly et.al 2005:16). Through their technological experiences and orientation learners could "actively create meaning from what is encountered in the environment" (Tapscott 1998: 34). Tapscott (1998) further identified a new learning approach whereby people learn best by doing rather than simply being told. This approach is based on the fact that knowledge is constructed as learners try to make sense of their experiences (Newby et al 2011). It is therefore necessary to engage learners in practical problem solving. In light of this, Tapscott (1998) argued that learning environments and curricular should not be designed by teachers only, they can however, be designed in partnership with the learners or by the learners themselves.

To teach and learn with technology needs support. Participants continuously mentioned lack of support in terms of resources and infrastructure. They view lack of support as the responsibilities of stakeholders such as the principals, school governing bodies and the department of education. These stakeholders have to ensure that standard resources are available and sufficient for activity based teaching and learning to be achieved. The department of education need to revise the budget to support learner and teacher needs. A sound financial status can contribute to better and developed school environments, and it is solely the responsibility of the department of basic education. Shortage of resources results from overcrowding in the schools. The lower the learner enrolment, the better the class management. Lesser class enrolment will enhance individual attention and support in terms of concentration, sufficient resources, feedback on class and homework, and quality contacts between teachers and learners (The Education Foundation Trust, 2005).

1.8 CONCLUSION

The findings of this study are consistent with other studies as indicated in the above sections, but what was interesting in this study was not only the teaching of mathematics, but also finding a solution of teaching mathematics in the digital era. The digital nature of the world has captured every citizen's attention, therefore people have to turn away from a traditional mode of learning to a more digitalised learning. The impact of this transformation is huge on learners as

achievement in mathematics is not satisfactory. It is however best to find the solutions to the problem in hand. One such solution is to change our attitude in teaching. This will include the learning styles of the digital kids as well as the teaching approaches.

From this study it is therefore recommended that for effective teaching and learning in the 21st century classrooms should be transformed to cater for relevant technologies to mathematics instruction. Stakeholders should maintain that there is infrastructure that will cater for the new teaching approach.

Our discussion in this study has aimed to claim spaces for new ways of thinking about teaching and learning and assessment opportunities in digital environments. What is new in this work is the broad conceptualisation of opportunities designed to take account of the requisite foundational knowledge and essential digital learning. In order to induce learners to adapt to incorporating mathematics and technology, it is imperative to consider teacher expertise in teaching mathematics in the digital era. Different factors might pose a challenge to teachers in delivering the content to satisfy the needs and wants of digital kids. These factors might range from lack of knowledge or expertise on technology, lack of confidence in manipulating technological tools or material, lack of resources, lack of support for developmental purposes, classroom environment that does not cater for effective teaching and learning, to learners who do not cope with pen and pencil teaching, but would be excited by applying technology in their learning. In essence, this study complies with Berry et al (1997) who identified categories of teachers in the digital era. The authors explain these categories in the following manner. Flag wavers would perfectly fit in an environment where digital material is available, accessible and sufficient. Most learners would adapt and work with enthusiasm. Philosophers would in a way deliver the content perfectly in an environment where technology has not yet taken root i.e. where there is no single technological tool to complement teaching. In this case learners will be forced to remain in a paper-pencil and chalk-board era. General practitioners would adapt in an environment where resources are limited, where teacher flexibility is necessary, that is, the ability to move from technology centred method to a traditional method of pen and pencil, and vice versa. Based on the findings of the study, teachers in the study will therefore be classified as philosophers, because in most schools the technology has not yet been integrated to the teaching of mathematics.

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