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# Connectivism as a strategy to support progressed Mathematics learners through Information Communication Technologies

**A dissertation by**

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Submitted in partial fulfilment of the requirements for

**Philosophiae Doctor in Computer Integrated Education**

**Department of Science, Mathematics and Technology Education**

**Faculty of Education**

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## DECLARATION

"I Lineo Kolobe declare that the research which I hereby submit for the degree of Philosophiae Doctor in Computer Integrated Education at the University of Pretoria, is my own original work and it has not been previously submitted by me for any degree at this institution or any other tertiary institution."

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| **CLEARANCE CERTIFICATE** | CLEARANCE NUMBER: **EDU141/20** |
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## ETHICS STATEMENT

“I have obtained the research ethics approval to undertake this study from the University of Pretoria’s ethics committee and an approval from the Gauteng department of education. I declare that I have observed all set ethical requirements in terms of the university’s code of ethics for research and all policies guiding such. The researcher has further complied with Covid-19 safety protocols as set by the Government of South Africa and Gauteng Department of Education in undertaking this study”.

# DEDICATION

This dissertation is dedicated to my late father.

*“Don't ever give up.*

*Don't ever give in.*

*Don't ever stop trying.*

*And if you find yourself succumbing to one of the above for a brief moment,*

*pick yourself up, brush yourself off, whisper a prayer, and start where you left off.*

*But never, ever, ever give up.”*

Richelle E. Goodrich, Eena, The Tempter's Snare

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***"I know your deeds, your hard work and your perseverance", Revelations 2:2***

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## ABSTRACT

The introduction of progression policy, which prohibits the repetition of a grade to more than once within each of the four phases of Basic Education, was enforced in the Further Education and Training (FET) phase in 2013. The first group of progressed learners to write their National Senior Examination was in 2014. There have been conflicting views from various stakeholders within the education sector on the benefits and challenges of progression policy.

What studies do not address, are appropriate strategies that could be applied to support the progressed learners in Mathematics. This study was a comparative case study which investigated how connectivism can be used to support progressed learners using Information Communication Technologies (ICTs). The study aimed to describe the types of digital networks teachers use to support progressed learners, their impact and effectiveness, to track their performance and outline both the benefits and challenges of using connectivism as a support strategy for progressed learners, to compare with the existing strategies which are not necessarily technological used to support progressed learners and to create a framework which could be used to support progressed learners within a connectivism ideology.

Data collection strategies used were semi-structured interviews, questionnaires and documentations such as lesson plans, progression tracking tools and support policies. The study population was sixteen FET Mathematics educators from five secondary schools in Ekurhuleni North district in circuit 4. Data analysis was done through Atlas ti and presented in a descriptive and graphical way.

The findings of this study indicated that connectivism is a digital age theory, which when incorporated into teaching and learning, becomes one of the most effective support tools for progressed learners. The findings further indicated that ICTs within networks makes teaching and learning more learner centred, improves participation, learner attainment and pass rate. The findings also revealed that connectivism became the most critical way of learning not only as a support strategy, but the most effective way for remote learning and continuous learning. Learners are able to learn at their own pace, at their most convenient set-up and they manage and control what they learn, how they learn, with whom they learn and what information they require. The findings further indicated that although there are challenges such as resource distribution among participants, the benefits outweigh the challenges.

**Key words: Connectivism, FET phase, Information Communication Technologies, Mathematics educators, progressed learners**

# LANGUAGE EDITOR'S DISCLAIMER

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ENTITLED:

**CONNECTIVISM AS A STRATEGY TO SUPPORT PROGRESSED MATHEMATICS LEARNERS THROUGH INFORMATION COMMUNICATION TECHNOLOGIES**.

14 JUNE 2022

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## LIST OF ACRONYMS

| ACRONYM | MEANING IN FULL |
|---|---|
| DBE | Department of Basic Education |
| NCS | National Senior Certificate |
| GDE | Gauteng Department of Education |
| PISA | Programme of international student's assessment |
| ICT | Information Communication Technology |
| FET | Further Education and Training |
| SASA | South African School Act |
| CAPS | Curriculum Assessment Policy Statement |
| DOE | Department of Education |
| GET | General Education Training |
| NDP | National Development Plan. |
| DTPS | Department of Telecommunications |
| ICASA | Postal Services Independent Communications Authority of South Africa |
| USAASA | Universal Services and Access Agency of South Africa |
| TIMSS | Trends in International Mathematics and Science study |
| TSLN | Thinking School, Learning Country |
| RME | Realistic Mathematics Education |
| OECD | Organization of Economic Cooperation and Development |
| NAPLAN | The National Assessment Program – Literacy and Numeracy |
| MOE | Multiple examination opportunity |
| PLC | Peer Learning Community |

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# CHAPTER 1: INTRODUCTION

## 1.1 INTRODUCTION

Schooling in the 21st century has undergone major changes in the recent years. Some of those changes that have advanced into the South African educational system is the presentation of progression policy and the use of Information and Communication Technologies (ICT instructional technologies) to support and enhance teaching and learning. The Department of Basic Education (DBE) defined progression as "…the advancement of a learner from one grade to the next, excluding Grade R, in spite of the learner not having complied with all the promotion requirements" (DBE, 2013, p. xi). This policy was first introduced in relation to the General Education and Training (GET) phase (Grades R-9), and in 2013 a regulation was introduced to allow for progression in the Further Education and Training (FET) phase (Grades 10-12).

The South African School Act of 1996 according to DBE (1996) outlines how learners move from one grade to the next. The first is learners who are promoted to the next grade as indicated in CAPS Policy (DBE, 2011). The second criteria is the number of years in the phase and the third is the age a learner is in that grade termed age cohort (DBE, 1996). This means that a learner may not be retained twice in a phase and an over age learner must be condoned to the next grade to be on par with his or her age peers. This therefore means that even when a learner does not meet promotional requirements, he or she is expected be progressed to the next grade due to either age cohort or number of years in the phase (DBE, 2011). Both promotion and progression allude to the development of a student to a higher grade. Promotion is a result of the student having accomplished the least pass prerequisites specified for the evaluation by the schooling authority. Progression occurs despite not having achieved these minimal prerequisites (DBE, 2013).

The South Africa Department of Education (DoE), presently called the Department of Basic Education (DBE), embraced an arrangement that restricted repeating a phase to once in 1998 (DBE, 2011) and we allude to this as the progression policy. The progression policy was introduced in the FET phase in 2013, in reaction to an instruction given by the Minister of Basic Education (DBE, 2020).

In terms of regulations relating to the National Curriculum Statement Grade R-12, publicized on 28 December 2012, a learner may fail once in a phase to avoid spending more years in that phase (DBE, 2017). The consistency of the financial gap in the South African schooling system proceeds to imprint negative patterns of a learner's performance in poorer communities. While trying to address the imbalance impacting on students in schools, the Department of Basic Education conceived a different approach to help learners move to the next grade without having met the prescribed pass requirements in the CAPS policy (DBE, 2013).

The foundation of learning mediations over the course of the years have demonstrated a willingness to provide extra support for progressed learners, learners at risk as well as average learners who are borderline (DBE, 2017). Fundamentally, the differentiated approaches used for learners as interventions, are expected to address both content inadequacies that may keep learners from accomplishing an NSC, and work towards improving the nature of learning results (DBE, 2020). ICT instructional technologies is one of the best practices employed in high achieving countries such as Hongkong and Singapore to support and enhance learner performance (Jin et al., 2019 & Natarajan & Laxman, 2021).

Over and above what was prescribed in the South African Schools Act of 1996, which outlined progression requirements, there were further amendments, which were made and implemented. According to Circular 7 of 2020 cited in DBE (2020) an instruction was given to adjust marks by 5% for three subjects for senior phase learners who had failed, thus placing these learners into the FET phase. Moreover, there was a further requirement to condone Mathematics and progress the learners to the next grade regardless of failing Mathematics.

According to Circular E 35 of 2015 and Circular E 22 of 2016, there was a further outlined set of criteria, which prescribes how learners should be progressed within the FET phase specially to Grade 12. A 30% Mathematical pass requirement is no longer a prerequisite for promotion into Grade 12; there are other guidelines to be followed to pass a learner into Grade 12. These are:

- a learner should have at least repeated either Grade 10 or 11,
- should at least have passed three subjects in Grade 11 including language of teaching and learning (DBE, 2015 & 2016).

This implies that a learner, who fails either Grade 10 or 11 for the second time, may not be allowed to repeat, or a learner who failed Mathematics in the grade must be afforded an opportunity to be advanced to the next grade. This progressed learner however must satisfy all the NCS requirements in order to obtain his or her matric qualification.

Table 1.1 below is an outline of the promotional requirements as stated in the CAPS policy document. Each phase is allocated three years and a learner may not take more than four years in each phase; a learner is supposed to be moved to the next grade even if he or she did not meet the stated pass requirements. The expectation is that such a learner will be given extra support in the next grade to minimize the gap between him and high ability learners in terms of content comprehension.

**Table 1.1 Promotion requirements per grade (DBE, 2011)**

<table>
<tr><th>SUBJECTS</th><th>GRADE R</th><th>GRADE 1-3</th><th>GRADE 4-6</th><th>GRADE 7-9</th><th>GRADE 10-12</th></tr>
<tr><td>Home Language</td><td>4 (50%)</td><td>4</td><td>4</td><td>4</td><td>40%</td></tr>
<tr><td>First Additional language</td><td></td><td>3</td><td>3</td><td>3</td><td>40% or level 3 in two subjects</td></tr>
<tr><td>Mathematics</td><td>3 (40%)</td><td>3</td><td>3</td><td>3</td><td rowspan="2">30% in any three subjects but on condition that the failed subjects SBA component is submitted</td></tr>
<tr><td rowspan="2">Other</td><td rowspan="2"></td><td></td><td>3 in any 2 other subjects</td><td>40 % in any three subjects<br>30% in any two other subjects</td></tr>
<tr><td></td><td colspan="3">A learner may be condoned in one (1) learning area on condition that a learner needs a 2%, maximum to get a pass at 30% or 40%.</td></tr>
</table>

Table 1.1 above further gives a directive on promotional requirements of learners from Foundation phase to Further Education phase (FET). One interesting point is that there is no Mathematical requirement for promotion within the FET phase. The instruction on condonation changes every year. It is therefore to be noted that the percentage increase stated at this time of this study may be completely different in the next year or two. Recently, the number of learners retained within grades is increasing, thereby bringing into play the

progression policy (Reddy et al., 2015) and the necessary support these learners should be given to be able to achieve in Grade 12.

To address the low learner achievement within the education context globally, new methods and tools are being developed to motivate and encourage learners to participate in the understanding of existing knowledge and the construction of new ones (Vásquez et al., 2017). Progression policy and its impact therefore calls for a review of the entire education system in South Africa, thereby calling for new strategies which will address the impact of progressed learners in the general learner performance.

As indicated in the White paper 6 on E-Learning (DBE, 2014), the sole purpose of introducing ICT instructional technologies into South African schools was to support and improve the quality of learner performance especially in Mathematics and Science subjects for low ability learners (now termed progressed learners). This would be through ICT instructional technologies aimed at supporting progressed learners both in and outside school.

The South African government presented ICT in the learning process with the objective of offering valuable and relevant teaching and learning (DBE, 2004) and the idea of advancing the education system. Different advantages have been identified by a number of scholars with the incorporation of ICT; it has improved the appropriateness of the learning content, accommodated each learner who requires support, brought about new intervention strategies, making up for language inadequacy, expanding application conceivable outcomes just as enhancing the verbally expressed word (Singh & Chan, 2014 & Walker et al., 2017).

Moreover, ICTs can provide teachers with gadgets to support open and remote learning (Makura, 2014, p. 43; UNESCO, 2012). Admittance to data and correspondence in the cutting-edge computerized world has been made simple and imaginative; a teacher can speak with students through current computerized gadgets outside the classroom. This improves how teaching and learning happens inside and outside the classroom. Teachers are the fundamental drivers in guaranteeing viable and appropriate incorporation of ICT in the classroom making their degree of information and abilities more effective. Singh and Chan (2014, p. 875) contend that ICT has the potential to deliver an amazing learning climate that changes the entire teaching and learning process.

The efforts from the Department of Basic Education to present and introduce ICT in the South African schooling system are for teachers and learners to have the option to compete equally globally (DBE, 2016). Anderson (2008, p. 6) notes that an information society comprises of a relationship of individuals with comparable interests who attempt to utilize their joined information. Individuals from an information society do not need to live in a similar area yet with the utilization of technology, it makes the sharing and access of data substantially more achievable (Siemens, 2006).

To accomplish and keep up quality schooling implies that the technique for teaching and learning should advance digitally and be aligned with the world's demands and to accommodate all kinds of learner abilities (Sinyosi, 2015). Beyers (2016) notes that in comparison African countries have similar challenges in terms of integrating technology into teaching and learning due to factors such as absence of adequate ICT framework, the digital divide and absence of appropriate teacher abilities and information incorporating ICT viably in the classroom, when contrasted with first world nations like the United States of America (USA) and United Kingdom (UK), which are profoundly advanced in class in the accessibility of ICT in the class and its usage in the process of learning (Beyers, 2016, p. 332).

The change in teacher pedagogy to accommodate ICT instructional technologies has brought in a different school of thought in teaching theories. It has been argued by Downes (2016) that the introduction of ICT instructional technologies called for a review of the existing educational theories thereby bringing into play the ideology of connectivism theory.

The connectivism theory brings to light the possibility of teaching and learning beyond the confines of a classroom and with assistance of ICT instructional technology models (Walker et al., 2017). Siemens (2005, p. 7) describes connectivism as a "model of learning for the digital age where learning is not only an internal individualistic activity, but an ideology that knowledge is distributed across networks and connections". It puts forward an ideology of learning which is based on creating knowledge networks which are online based in the teaching and learning process (Cerny, 2015). Connectivism outlines the impact of ICT on learning, but it extends beyond a classroom (Vas et al., 2018) and it occurs through the formation of connections using networks to acquire or disseminate knowledge (Strong & Hutchins, 2009).

Advocates of connectivism such as Downes (2016), Floris (2014) and Rabah (2015) believe that this theory closes a gap in learning in the era of technology. Its impact has an influence on the learner promotion and progression structure of schools.

What elicits much interest is how ICT instructional technologies support the teaching and learning of progressed learners, as compared to not using ICT support strategies and ways in which teaching and learning expands beyond the classroom, as advocated by Siemens (2005) to support Mathematics progressed learners.

This research examined progression policy in South Africa and described the application of ICT instructional technologies within a connectivist ideology to support progressed learners in Mathematics. The study further gave a description of how ICT instructional technologies are applied both inside and outside school to support teaching and learning of low ability learners who were progressed to Grade 12 in Circuit 4 Ekurhuleni district in Gauteng. The study further investigated the benefits and shortcomings of using ICT instructional technologies as a tool for support for learners who are progressed in a connectivist classroom set up. A further comparative study was conducted to outline the difference between not using ICT instructional strategies and the use of ICT instructional technologies to support progressed learners. This research further outlined the recommendations to promote and integrate the use of ICT and non-ICT instructional technologies in teaching and learning to support progressed learners in Mathematics. The study concluded by creating a framework for supporting progressed learners using both ICT instructional technologies and non-ICT instructional strategies.

## 1.2 BACKGROUND

The constitution of South Africa, Act 196 of 1996 made education a priority making it a basic human right. Post-apartheid, an Outcome Based Education policy was introduced and put into practice in 1996 (Manqele, 2012). To improve the mathematics achievement and ensure that all learners are supported, the government created a National Strategy for Mathematics, Science and Technology Education of 2001 which was aimed at improving the Mathematics subject's attainment even for previously disadvantaged learners (Kriek & Grayson, 2009).

This saw the birth of special projects such as Dinaledi which purpose was to improve the learner's performance in Mathematics and Physical Science from Grade 10 to 12. This programme further aims to improve the educators' pedagogical and content knowledge as well as improving learner attainment (Mafukata, 2016).

As further indicated by Spaull (2013), several strategies were developed to address the low performance in Mathematics which among others included the introduction of ICT in teaching and learning. According to Mafukata (2016), improving the quality of education became the most important objective of the National Development Plan (NDP). Although much has been put into place in terms of policy, in South Africa there is still limitations hampering the envisioned positive outcome especially in Mathematics and Science subjects (Sinyosi, 2015).

Some of these complexities and constraints have been classified as institutional, technical, pedagogical and anthropological among others (Sinyosi, 2015; Zimasa, 2016; Spaull, 2013). These challenges were prevalent in Mathematics in schools in South Africa to date (Reddy, et al. 2015). Over 25 years of various implementations of policy, the country is still unable to close the gap and bring an improvement to learner performance, especially in Mathematics. This inability to improve in Mathematics brought about a new policy which was aimed at progressing learners even with the evidence of their failure in Mathematics.

Instead of retaining learners who failed to achieve a 30% in Mathematics as a prerequisite of the CAPS, the progression policy was introduced and according to Sinyosi (2015) this means that learners were pushed to the next grade without complying with all the set requirements of promotion as outlined within the CAPS policy. This policy is implemented through SASA 1996, outlining progression because of age and number of years in the phase, Circular 1 of 2017 which emphasizes the condonation of Mathematics in the senior phase and FET (DBE, 2017) and mark adjustment where a learner is given 5% in Mathematics or other subjects to be able to progress (DBE, 2015) in Circular 3 of 2015 and Circular E 35 of 2015. The matric pass requirement and universities' entrance requirements still remain unchanged despite the introduction of progression policy. Universities still require a Mathematics pass for entrance into their Mathematics, Finance and Science faculties.

This therefore means that the condonation of Mathematics has a potential to reduce the number of university entries into Mathematics and Science subjects.  This could therefore see a decline in Science and Mathematics related professionals in the long run. One of the interventions the Department of Education introduced with White paper 6 on E Learning, according to DBE 2014, was to introduce ICT as one of the support strategies for progressed learners.

In 2007, the Department of Basic Education made further strides in guaranteeing that schools increase ICT access, where they came up with a guideline that plans to improve the ICT knowledge, abilities, qualities and perspectives required by educators to deliver the curriculum successfully (DBE, 2014). Peters (2017) contends that it is essential for educators to have fitting ICT abilities and information, as ICT on its own won't unexpectedly change performance of learners especially low ability learners, however it requires the responsibility and commitment and the know-how of educators to use ICT in a way in which it will benefit all learners.

In 2014, the Department of Basic Education teamed up with the Department of Telecommunications and Postal Services (DTPS), Independent Communications Authority of South Africa (ICASA), Universal Services and Access Agency of South Africa (USAASA) and Network Operations (Mosehlana, 2018) to improve access of ICT infrastructure in schools. Every single division assumed a part in guaranteeing that schools coordinate and improve their ICT. The Department of Education in Gauteng further gazetted their ten pillars of education, one of which is pillar no 6, with the objective to improve ICT accessibility and usage in Gauteng schools.

Looking at the progressed learner's performance in Matric since the inception of this policy, the research study basically focused in describing how Circuit 4 Mathematics educators use ICT instructional technologies to support progressed learners and compared it with non-ICT instructional technologies used to support progressed learners. The study further presented a framework of support strategies which are applicable to ICT and non-ICT schools.

### 1.3 PROBLEM STATEMENT

Every beginning of the year South Africa's Department of Basic Education releases the National Senior Certificate results for the previous Grade 12 learners, and these are referred to as the "matric results" and they are used to regulate admission and admission into higher institutions. About 81.3% of those who wrote the matriculation exams in 2019 passed (DBE, 2020). This pass rate was much celebrated as it marked a major improvement compared to the 2018 pass rate (DBE, 2020).

What was of much concern from these results, is what Minister of Education, Angie Motshekga, said about the drop in performance in Mathematics. This is one of the most important subjects which is considered important for the country's growth economically.

This decline was twofold: there was a decline in the number of students writing the pure Mathematics as most progressed learners opt for Mathematics Literacy in the examination from 270,516 in 2018 to 222,034 in 2019 (DBE, 2020). The second determinant was the fact that only 54% of the learners passed Mathematics. This is a decline in comparison to 58% in 2018 (Mokotjo & Mokhele, 2021). In order to pass in Mathematics a learner must obtain 30% (DBE, 2017). The implication is that about 54% of Mathematics exam candidates obtained at most 30%. It was reported that 4,415 learners obtained a distinction pass which constitute a 2% in total. A distinction is a score of 80%-100% and this is down from 2.5% in 2018.

In her address to the 2017 Mathematics indaba, Minister of Education, Angie Motshekga said, "*South Africa is significantly underperforming in education in general, particularly in Mathematics teaching and learning. Mathematics teaching is often of a poor quality, with teachers not able to answer questions in the curriculum they are teaching, one indicator of the challenge*." (DBE, 2017). The aim of the indaba was to come up with strategies to remedy the low achievement in Mathematics performance. According to the Department of Basic Education (DBE, 2017), the indaba would "place the teaching and learning of Mathematics within the public schooling system boldly on the radar."

The South African Mathematics performance challenge is not only evident in the South African matric results, but it emanates from the performance of lower grades. In a study conducted from 2003 to 2011, Reddy et al. (2016) called Trends in international Mathematics and Science study (TIMSS), South Africa obtained a Mathematical score of 372 and a Science score of 358 by learners doing Grade 9 in 2015. South Africa was ranked the lowest performer of the 39 countries which took part in this examination. 34% of Mathematics learners and 32% of Science learners achieved a score of over 400 points in 2015. This therefore denotes that only a third of South African Grade 9 learners achieved a minimal level in Mathematics and Science (Reddy et al., 2016).

There is significant evidence to point out that South Africa is faced with a serious challenge in terms of learner performance, especially in Mathematics thereby adopting the progression policy which aim is to ensure that learners are at least not stagnant in one grade or phase (Moayyeri, 2015).

According to Spaull (2013) and Reddy et al. (2015), one of the common reasons cited behind the progression of learners is to minimize the number of learners dropping out ensuring that at least they attain the National Senior Certificate (DBE, 2015). It is therefore assumed that it is better if a student is progressed and given extra support thereby creating a chance of completing Basic Education (DBE, 2017).

This rationale has been challenged by educators, according to Zimasa (2016) and Nomahlubi (2018). Educators are faced with a challenge of teaching a mixed large classroom of high ability learners and progressed learners especially in previously disadvantaged schools, and it is expected that these learners should by the completion of the academic year, be on the same academic level. High ability learners are expected to be achieving at a high level while low ability learners are supposed to be supported to achieve better marks in one mixed class of an average of 50 learners (Sinyosi, 2015).

Secondly, it is expected that the learners who had failed Mathematics in lower grades and were condoned to FET should be supported and achieve a higher score in their final matric year.

Gajewski and Mather (2015) cite that the problem of progression is that it is a notion of moving learners through the schooling system and has a potential to increase drop out. Moreover, even though retaining could assist learners in the short term, advantages in the long-term may not be ascertained, repeating a grade sometimes may not yield the intended results especially to learners who are already over age specific for that grade (Scherer et al., 2017). Retained learners further run a risk of being quite older and out of their age cohort in a certain grade bearing a number of socio and emotional implications for such learners (Jimerson, 2001; Jacob & Lefgren, 2007).

When learners are progressed but not given enough support, it also poses long term consequences for learners who become economically unproductive. It is estimated that more than 66% of learners leave school before the completion of Grade 12 and the majority have indicated academic difficulty at school and that no form of support was given (Scherer et al., 2017). In a 2018 interview, the Gauteng MEC for education, Mr Lesufi Panyaza indicated that: "As a province, we committed resources and expertise to ensure that progressed learners are given a fair chance of completing school with a minimum loss of time. We have provided progressed learners with comprehensive supplementary programmes in schools and in study camps over weekends and holidays" (Nomahlubi, 2018). What further remains a challenge is educators are not capacitated to support or offer remedial lessons to progressed learners or have the know-how of how to manage mixed large classrooms while striving to complete the syllabus (Zimasa, 2016).

Reddy et al. (2015) indicate that the rate and the level of progressed learners' content comprehension varies from those of high ability learners. Material sources, pace, teaching styles, theories and classroom set up should be reviewed to accommodate progressed learners. One of the methods advocated is the use of ICT instructional technologies and connectivism approach in learning by Siemens (2005). In schools as echoed by educators interviewed by Zimasa (2016), many educators are unconvinced of the feasibility of meeting the educational needs of both high performing learners and progressed learners in the same classroom, and they indicated that they have not received the professional training to make this possible.

What therefore remains a challenge is, underachieving learners are continuously being moved to the next grade, but educators are not capacitated with the know-how to support these learners or manage mixed classes. From various interviews with the Minister of Education, Mrs. Angie Motshega (DBE, 2015; Zimasa, 2016) resources are put in place such as budget for extra lessons, but improved strategies to be employed to support progressed learners are yet to be developed and tested. It rests upon each school and educator to do his or her own research of the effective strategies he or she could employ to assist these learners to close their academic gap.

The main identifiable challenges are that educators are faced with a challenge of supporting progressed learners while on one hand they have to complete a syllabus and ensure that high ability learners achieve at an expected pass rate. The second challenge is that educators lack the know-how on support strategies. The third challenge is there is no blueprint or framework which teachers can use as a guide to support progressed learners either using ICT instructional technologies or non-technology. It is therefore rests upon each teacher to find best practices and apply them in his or her class to support progressed learners.

### 1.4 THE RATIONALE

According to Arends et al. (2017), being able to offer quality education is the most important human right. All learners deserve quality education regardless of their learning ability. What is of outmost importance is the significance, relevance and productivity of education offered at schools to progressed learners which will enable them to participate positively in the country's economic growth. What needs to be researched is what type of support and strategies are offered to low ability learners in Mathematics who are progressed to the next grade due to failure of Mathematics.

The study strived to find out the role ICT instructional technologies play in supporting progressed learners using connectivism ideology. Secondly, the study compared the ICT instructional technologies with non-ICT instructional technologies. Thirdly, the study came up with an intervention strategy framework which can be used to support progressed learners in any school (both highly resourced and less resourced).

Learning has evolved through the years, new generations of learning does not need structure; teaching and learning can occur anywhere using connections both human and digital (Strong & Hutchins, 2009). Leithwood and Jantzi (2006) assert that, at times classroom teaching may not be as effective as expected due to the educators' teaching styles. Coe et al. (2015) explain active teaching as an act of improving learner attainment measured through set objectives. The rationale of this study is to determine if connectivism could be one of the best suited theories to be applied to support progressed learners using ICT instructional technologies.

A further contribution of this study is that other theories do not consider the changes brought into teaching and learning by technology. Connectivism as argued by Siemens (2006) and Downes (2007) is a theory which aims to fill the gap in the teaching and learning in the digital world, therefore the other reason in undertaking this study is to collect such evidence which supports this theory.

## 1.5 THE IMPORTANCE OF THE STUDY

Progression policy is a critical concept which existence needs to be accompanied by various strategies, resources, a change to teaching styles and theories. The study described the use of ICT instructional technologies and non-ICT instructional technologies comparatively, to support progressed learners in Mathematics. The study further came up with an intervention strategy framework to be used to support progressed learners.

Using ICT instructional technology, the study further investigated the effect of connectivism towards supporting progressed Mathematics learners. The process of knowledge acquisition using nodes and connections as components of connectivism, and its implementation and effectiveness were explored. Knowledge acquisition does not rely on a single information source, but an interaction with society to build knowledge (Strong & Hutchins, 2009). The role of both the educator and the learners and the support methods employed, and the interactions and networks created during the process of learning, were explored in the knowledge acquisition processes using ICT.

Connectivism theory investigates ICT instructional technologies where networks are formed and applied (Siemens, 2006), to enhance teaching and learning. This study looked deeply into network formation and functions, which were intended to support low ability learners using ICT instructional technologies, knowledge creation and sharing with networks. As explained by AlDahdouh et al. (2015) ICTs play an integral role in the classroom. This study looked deeper into the role played by ICT instructional technologies in creating a network of teaching and learning which is intended to support progressed learners. The study compared such strategies with non-ICT instructional technologies and created a working document which can work as a framework for intervention to support progressed learners in Grade 12 Mathematics.

This study is important because it further fills an academic gap in the literature in the application of connectivism as a support strategy aimed at supporting progressed learners using ICTs. It moreover contributed to the discourse of strategies both technological and non- technological which could be applied to support progressed learners in South Africa.

The significance of the research programme is aimed at examining the findings of the research study, come up with conclusions with the expectation of ensuring viable and appropriate implementation of support strategies in schools, and that the research findings can be used in teacher professional development in regard to the effective use of support strategies for progressed learners.

### 1.6 OBJECTIVES OF THE STUDY

This study wanted to:

- describe how ICT and non-ICT strategies can be used to support progressed learners and their impact in Grade 12 Mathematics using connectivism theory.
- describe the type of digital networks used to support progressed learners.
- to describe how connectivism theory and ICT instructional technologies can be used to support progressed Mathematics learners.
- assess the effectiveness of digital networks as support strategies teachers use.
- track the performance of progressed learners supported using connectivism as a strategy.
- describe the benefits and challenges in supporting progressed learners in Mathematics with ICT and non-ICT instructional strategies.
- compare the non-ICT strategies and ICT strategies used to support progressed learners.
- design a framework to support progressed learners in Mathematics in Grade 12.

## 1.7 RESEARCH QUESTIONS

Based on the above objectives and rationale of this research, the questions were designed as follows.

### MAIN QUESTION

How can ICT instructional technologies and connectivism theory be utilised to support progressed Mathematics learners?

### Sub questions

- What ICT and digital network strategies can educators use to support progressed learners in Grade 12 Mathematics?
- What type of digital networks can assist in supporting progressed Mathematics learners?
- What is the effectiveness of the current support strategies on progressed Mathematics learner performance?
- What other strategies exist to support progressed Grade 12 Mathematics learners?
- What are the benefits of using ICT and non-ICT instructional technologies to support progressed learners?
- What are the challenges educators encounter in supporting progressed learners in Mathematics with ICTs and non-ICTs instructional technologies?
- How can connectivism theory and ICT instructional technologies be used to support progressed Mathematics learners?

## 1.8 THEORETICAL FRAMEWORK

The theory that supported this study is the connectivism learning theory. I discovered the theory to be suitable for the research as it offers clear understanding of how ICT can be incorporated to improve teaching and learning both inside and outside the classroom to support low ability learners. The connectivist theory presented by Siemens (2004), specifies that learning does not really live just in the classroom but from any place and through various channels. As per the connectivism theory which is a structure for understanding learning in the digital age (Downes, 2016), learners and teachers can learn and share information and data through links and networks that incorporate personal associations, non-people, students and educators from any place on the planet. This theory is explored further in Chapter 2.

## 1.9 RESEARCH METHODOLOGY

The study's methodology discussed the research paradigm, the approach of the research and the design, as discussed below.

### 1.9.1 THE RESEARCH PARADIGM

Guba (1990) asserts that the paradigm in research characteristically mirrors how the researcher sees the world. Kivunja and Kiyuni (2017) portray a paradigm as a focal point through which a researcher looks at the world, and the crucial factor about a paradigm is that it gives beliefs and directs researchers on what to study, the specific order, impact on what ought to be researched, how it ought to be studied and how the findings should be analysed and interpreted.

There are three fundamental paradigms useful in educational research, being the positivist, critical and interpretivist paradigm. The positivist worldview includes an experimentation cycle that is utilized to investigate perception related to responding to questions, pointed towards giving clarifications and making assumptions based on expected results. Kivunji and Kuyini (2017) note that the critical paradigm looks to address the political, social and financial issues which influence societal persecutions, conflicts, struggle and power structures at any levels these might happen.

In contrast to other paradigms, the interpretive worldview looks to understand the world where participants reside or work, with the objective of the research depending as much as conceivable on the participants' perspectives on the circumstance (Kivuni & Kuyini 2017). This investigation applied the interpretive worldview on the grounds that it looks to comprehend the impression of teachers regarding the incorporation of support strategies for progressed Grade 12 Mathematics learners. A deeper discussion of the paradigm will follow in Chapter 3.

### 1.9.2 THE RESEARCH APPROACH

The nature and focal point of the investigation and the set research questions recommend that the suitable study approach utilized in this investigation is the qualitative research approach. This approach utilizes strategies that characterize the phenomenon in their complexity (Leedy & Ormrod, 2005, p. 133). The application of a qualitative research approach helped me in acquiring a better comprehension of the perspectives, assessments and view of the participants. The qualitative research depended on data collection through semi-structured interviews, questionnaires and document analysis.

Furthermore, research methodological procedures gave a fundamental portrayal of the research techniques and strategies (Durrheim, 2004). It further helped with the verification of the research. The investigation expected to detail the selection of participants' data collection methods and their analysis. A detailed description will follow in Chapter 3.

### 1.9.3 THE RESEARCH DESIGN

This study implemented a descriptive comparative case study, which tried to describe a phenomenon within its genuine and original setting where the limits between phenomenon and the context were clear and in which various sources were utilized (Yin, 1984, p. 23). Considering this, a descriptive comparative case study was considered fitting for this research, reason being that it described the phenomenon and described it from the viewpoint of participants as they experienced it, suggesting researching a perspective in a top to bottom way. The instance of this examination was to get further understanding on the elements of how teachers apply and perceive the effectiveness of different support strategies in a progressed Mathematics classroom. Hancock and Algozzine (2006, p.11) further stated that a case study gives the researcher deeper comprehension of the circumstances and what it means to the participants, and this notion has further been discussed in Chapter 3.

### 1.9.4 SAMPLING OF PARTICIPANTS

The determination of participants in the research helped me with accomplishing the study's objectives. Sampling within a qualitative study is a term utilized for the identification and choice of participants. Gentles et al. (2015) characterize sampling in its broadest sense as the choice of explicit information sources from which information is gathered to address the research objectives.

To choose participants for this study, I applied purposive and convenient sampling, as I was at that point mindful of the required qualities that the participants needed to have for this particular study and their accessibility to the researcher. Chilisa and Preece (2005 p. 170) depict purposive sampling as "being chosen from a group of participants". Convenience sampling (otherwise called haphazard or accidental sampling) is a kind of nonprobability or non-random sampling where individuals from the population targeted possess a certain set of criteria; easy to reach, topographical nearness, accessibility at a specific time, or the readiness to take part are incorporated in the investigation (Etikan et al., 2016 p. 2).

The chosen participants were secondary school teachers from Grade 12 Mathematics classes in Circuit 4 Ekurhuleni districts who used different strategies to support progressed learners. As I engaged with the principals of the five selected schools, I discovered that they usually allocate two or three educators to teach Mathematics in Grade 12 depending on the size of the school. All the available grade 12 teachers using ICT and not using ICT in the five schools were sampled. Further elaboration on the selection of participants is done in Chapter 3.

### 1.9.5 DATA COLLECTION

Qualitative research has four strategies they can use for gathering information which are observations, interviews, document analysis and visual audio materials (Kankam, 2019). As a researcher I opted for semi-structured interviews, questionnaires as well as document analysis looking specifically at relevant policies towards progression and teacher's lesson plans which worked towards attaining reliability and accuracy of data collected (Azungah, 2018).

Bell et al. (2018, p. 1142) concur that in doing this, the researcher obtains reliable information because of the application of various data collection methods. The principal technique I utilized was semi-structured interviews, where participants answered a set of semi-structured questions. McIntosh and Morse (2015) emphasize that semi-structured inquiries are non-mathematically presented and similar questions are administered to the participants. The semi-structured interviews were pre-decided inquiries that participants addressed based on the research. The meetings were telephonically recorded and transcribed. The second method used to collect data was a questionnaire and the third data collection method was through an analysis of policies on progression and teachers' lesson plans. Chapter 3 gives a thorough outline of the data collection methods applied in this study.

### 1.9.6 DATA ANALYSIS

Qualitative data analysis deals with the description, classification and interconnection of findings (Awdoziej, 2015). This study used Atlas ti to code, classify and analyse data. As seen by Friese (2014) the use of Atlas.ti in supporting the process of analysing data is viewed to have huge potential in bringing more rigor and trustworthiness to qualitative research of the case study, hence, the researcher preferred to use the software regardless of the number of respondents in the research to code and break down the information gathered. Hwang (2008) also advocates the utilization of Atlas.ti for its empirical advantage of improving credibility by making the research process more straightforward and replicable. Indeed, with the number of respondents, it was conceivable and simpler to create a case study dependent on individual respondents in this research.

### 1.9.7 TRUSTWORTHINESS

Lincoln and Guba (1985) express that trustworthiness relates to how the researcher can persuade the readers that the findings of the study and the investigation are of a high quality. To accomplish this, the qualitative examination needs to build up trustworthiness by striving to attain rigor to guarantee that the outcomes merit focusing on. Mellor (2021) portrays rigor in qualitative terms as the most ideal approach to build up trust in the discoveries of a study. Lincoln and Guba (1985) distinguished four segments of trustworthiness that are pertinent to the qualitative research. The four parts comprise of credibility, transferability (applicability), dependability (consistency) and confirmability (neutrality). The trustworthiness model and its four parts are investigated and further outlined in Chapter 3.

## 1.10. ETHICAL CONSIDERATIONS

Research includes community-oriented work through collaboration and coordination among various people, prompting the advancement of moral estimates like trust, decency, common regard and responsibility (Resnik, 2013). According to Bell (2010) a researcher needs to consider certain moral estimates when doing research like the wellbeing and safety of participants. Participants ought to know the aims and objectives of the study, and full consent by the participants ought to be given before the investigation. Before the researcher conducted this study, an ethical clearance from the University of Pretoria to do the research at the chosen schools was obtained. Moreover, the researcher applied for and got consent from the Department of Education in Gauteng to get into the schools and from the schools' principals to meet the educators. Prior to the meeting, I explained the aim of the study and obtained the participants' consent. A discussion of ethical considerations is outlined in Chapter 3.

## 1.11. CLARIFICATION OF CONCEPTS

It is vital to give clarity on various concepts as applied in this study.

### 1.11.1 INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs)

ICTs are utilized to pass on, control and store information by electronic methods, for example, email, SMS instant message, video and online web-based media. Moreover, ICTs incorporate distinctive computing gadgets like laptops, desktops and cell phones that can convey a wide scope of correspondence and data capacities (Christensen et al., 2018). ICTs have been argued to have the potential to improve the quality of teaching and learning. The utilization of ICTs in instruction opens another universe of conversation and interaction and sharing of information not just in South African classrooms but around the world. The integration of ICTs in teaching and learning includes the utilization of the internet, other digital appropriate devices, copiers and printers (Benedek & Molnár, 2014).

### 1.11.2 PROGRESSION

The Department of Basic Education (DBE) characterized progression as "… the movement of a student to the next grade, regardless of the student not having consented to all the advancement prerequisites" (DBE, 2013, p. xi). This strategy was first introduced in connection with the General Education and Training (GET) phase (Grades R-9), and in 2013 a guideline was presented which took into consideration progression in the Further Education and Training (FET) phase (Grades 10-12). Regarding guidelines identifying with the National Curriculum Statement Grade R-12, pitched on 28 December 2012, a student may fail once in a phase and should be moved to the next grade to try not to spend more years in that phase (DBE, 2017). While attempting to address the poor performance of learners in schools, the Department of Basic Education considered an alternative way to assist learners to reduce high rates of retention and possible drop outs.

Far beyond what was recommended in the South African Schools Act of 1996, which laid out the learners' movements, there were further revisions which were made and carried out. As indicated in DBE (2020) a guidance was given to increase marks by 5% for three subjects which they failed in senior phase progressing them into the FET phase. In addition, there was a further instruction to condone Mathematics and progress the students regardless of their performance in Mathematics.

As indicated by Circular E 35 of 2015 and Circular E 22 of 2016, there was a further arrangement of rules which guide how a learner ought to be advanced inside the FET phase. 30% Mathematics pass necessity is not, at this point an essential for advancement into Grade 12. There are different rules to be applied to pass a student into Grade 12. These are: a learner should have at least failed either Grade 10 or 11, a learner ought to have passed three subjects in Grade 11 including the language of teaching (DBE, 2015 & 2016). This infers that a student who fails either Grade 10 or 11 for a subsequent time or a student who failed Mathematics in the examination should be permitted to advance to Grade 12.

### 1.11.3 CONNECTIVISM THEORY

This is a theory introduced by Siemens which supports teaching and learning in the digital age (Siemens, 2006). It basically indicates that teaching and learning does not reside with a teacher or just within a formal classroom. According to Downes (2016) who also advocates for connectivism, knowledge resides not only within humans but also through various digital sources such as the internet. Connectivism relies on knowledge development and sharing through the use of nodes, links and networks and does not necessarily need to be formal. These networks are groups of connections people make who may not necessarily reside in one area, or in the context of teaching and learning, may not even be in the same classroom setting. Mattar (2018, p. 77) notes that "teaching and learning is no longer a process which is solely under the control of an educator but can take place even outside the conforms of communities".

### 1.11.4 TEACHING

Teaching is a cycle where a teacher imparts knowledge to learners with the viewpoint of fulfilling the requirement to learn and to assist them in becoming productive members of the society. Teaching alludes to a human endeavour with the expectation of assisting others with learning (Du Plessis & Conley, 2007, p. 3). Incorporation of ICTs in learning is a functioning practice which equips learners in being competitive in the global information society.

## 1.12 DIVISION OF CHAPTERS

The study is made up of six chapters, each chapter outlining a specific focus. The chapters' structures are detailed below:

### 1.12.1 CHAPTER 1

Chapter 1 introduced the background and outline of the investigation. The researcher discussed the study expectations and what inspired the investigation. The research problem that spurred the research and which went about as a guideline for the entire research was outlined. The section gave the objectives which this investigation planned to accomplish. The research questions that I needed to answer were expressed in the section. In this chapter, the reader was given a concise methodology which included the research paradigm, research approach and design. The data collection methods were stated as semi-structured interviews, questionnaires and review of relevant policies. The methodological norms were recognized and the ethical measures that were executed in this study, were addressed. The last section involved the explanation of the key terms.

### 1.12.2 CHAPTER 2

Chapter 2 outlines the theoretical framework guiding this study. In an effort to discover what different researchers have uncovered with respect to the study, the section contains a review of related literature and research identified with the concept under research. The chapter outlined the instructional methods of teaching and learning in the digital age using connectivism. The connectivism learning theory which I selected with the objective of learning its efficiency in the incorporation of ICT towards teaching and learning was introduced, and its principles were assessed. The chapter also investigated the Mathematics performance locally and globally and it reviewed the South African Mathematics performance of Grade 12. The chapter further investigated the global use of ICT in teaching and learning and intervention strategies for the high performing countries in Mathematics. It concluded by describing the digital support strategies for low ability learners in Mathematics.

### 1.12.3 CHAPTER 3

In Chapter 3 the research explores and describes the rationale for collecting, classifying, coding, analysing and storing data. Using the qualitative research approach, data was collected through semi-structured interviews, questionnaires and document reviews. The research design is outlined, and sampling techniques are outlined. Trustworthiness issues are addressed, and the chapter ends with a discussion of the ethical measures used in this study.

### 1.12.4 CHAPTER 4

Chapter 4 gives an outline of how the data is structured and the data analysis results of the study. Themes are created and patterns identified and presented in this chapter. The data collected is in three folds, the first is responses from the semi-structured interviews, secondly questionnaires and lastly document analysis of progression policies and lesson plans at the selected schools.

### 1.12.5 CHAPTER 5

Chapter 5 gives a broad analysis of the research findings; it strived to draw similarities between the literature and the findings from the semi-structured interviews, questionnaires and document analysis. The findings describe the use of ICT to support progressed learners in a connectivism theory as well as strategies not involving any technology. It addresses the following main question: how can ICT instructional technologies and connectivism theory be utilized to support progressed Mathematics learners?. It draws the similarities and indicates the differences in the participants’ opinions.

### 1.12.6 CHAPTER 6

Chapter 6 is a designed framework of a support strategy which embeds both an ICT and non-ICT instructional technology model, which will be recommended for development and use in South African schools as a common strategy which would be used to guide in the support of low ability or progressed learners.

### 1.12.7 CHAPTER 7

Chapter 7 gave recommendations and concluding remarks on the study. Firstly, it summarised the study and outlined the limitations in this study. This chapter further indicated how the study should contribute to both the policy making and to the literature. Recommendations of this study are outlined, and conclusions drawn.

### 1.13. CONCLUSION

In this chapter, the following were discussed: introduction of progression policy in the use of ICTs in the teaching and learning and the application of connectivism using ICT to support progressed learners. The background of the study was given, and the research questions were outlined followed by the study's rationale, aims and objectives. This chapter further gave a brief outline of the methodology, which was used, how data was collected, the study population and how data was analysed. The following chapter gives a comprehensive literature review. The chapter outlines broadly other researchers' findings in relation to support strategies used for Grade 12 Mathematics learners.

# CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

## 2.1 INTRODUCTION

The review of literature firstly investigated a number of scholarly views relating to ICT usage, its benefits and challenges in teaching and learning. The proceeding subsection of the review looked at the strategies to teach low ability learners both technologically and non-technologically to improve their performance in Mathematics.

This review secondly explored the general world of Mathematics performance and various strategies employed by highly performing countries based on PISA and TIMSS standardised benchmark assessments.

The third part of the literature review explored the South African Mathematical performance, both international benchmarks tests and the National Senior Certificate (NCS) performance since the inception of progression policy, and what scholars' viewpoints are regarding improving the learner performance in Mathematics. This section further took a deeper look into progression policy, its background and the perceived advantages in South Africa.

The last part of this study reviewed how connectivism can be applied within ICTs to support progressed learners and which gap connectivism fills as compared to other theories. A conclusion was drawn that connectivism when used with ICTs is effective in improving learner performance.

## 2.2 INFORMATION AND COMMUNICATION TECHNOLOGIES

As explained earlier, ICT alludes to visual, sound, printed or written work that permits easy access to attain information world-wide (Das, 2019). With various kinds of ICTs that exist, I feel that it is pivotal to explain the ICT instructional strategies that are utilized in supporting progressed learners in or outside an advanced classroom and their significance (Viberg et al., 2021).

ICTs include all technological gadgets utilised to promote teaching and learning, with the rapid global change brought in by technology either in the workplace, home and schooling, and the importance of incorporating ICT into teaching and learning is stressed (Ting et al., 2019). The current society in the 21st century is expected to critically think, collaborate and communicate in order to solve problems and technology plays an integral role in facilitating such discourse (Smidt et al., 2017).

Globally, it has been noted that the increase in the integration of ICT instructional technologies into teaching and learning prepares learners to be global citizens (Shaffer, 2006). Computer integration in teaching and learning improves the teacher pedagogy but further enhances a learner's ICT interactions in the digital world (Satrya et al., 2016). Samanta (2020) indicates that ICT competent learners are referred to as a new generation or digital natives. ICT is the combining of networks, software as well as the hardware as a platform to create and share information and knowledge in a digital advanced classroom (Rambe & Bere, 2013).

ICT instructional technologies occur in an advanced classroom atmosphere. An advanced digital classroom is a teaching and learning space digitally upgraded, where teachers, learners and technological gadgets are involved in knowledge formation (Das, 2019). The rationale behind the computerized or digital classroom is not to replace the teacher's role in class, but to make teaching and learning simpler as well as addressing the requirements of a technologically advanced generation and growing advanced links with the world. ICTs incorporated for educating and learning includes a wide scope of computerized instruments utilized in the advanced classroom (Das, 2019).

Hinostroza (2018) portrays ICTs as the most integral asset that can be utilized in expanding educational opportunities. Teaching using ICTs has demonstrated to be compelling and beneficial for both formal and non-formal schooling. As indicated by Snijders et al. (2018), ICTs have the capacity to rise above reality in a way that empowers teaching and learning anywhere, anytime without any constraints. Marange et al. (2021) note that ICT application expands teachers' abilities, confidence and eagerness and simplifies planned lessons.

The advantage of ICTs does not exclusively advantage educators concerning instructing; it likewise benefits the learners. Huang et al. (2020) agree by clarifying that by using ICTs, learners and teachers can cooperate among one another and even gain from each other from any place throughout the planet, as teaching and learning is not confined to a classroom or a region. The advantage of coordinating ICTs as an instrument to enhance teaching and learning can also be seen as a support tool to accommodate different learning abilities of learners (Hinostroza, 2018). The critical job that ICTs play in schooling has further influenced policy makers to come up with legal guidelines to incorporate ICTs into the teaching and learning frameworks (Parmigiani et al., 2020).

In an advanced ICT classroom, there is a variety of digital devices at each learner's disposal; their basic role is to assist and guide the process of learning (Marange et al., 2021). An advanced classroom encourages innovation, creativity, and collaboration (Naidoo, 2021). The ICTs utilized in an advanced classroom empower the transmission of curricular content in a fun, intuitive and imaginative way (Lopez-Perez et al., 2018).

The advanced digital class comprises of different mixed learning approaches which incorporates a blend of personal and online guidance, web-based learning (e-learning) stages, frameworks and instruments (Das, 2019). Another illustration of an advanced classroom is the "Flipped Classroom" which is alluded to as a learning model where learners get guidance on the web; they however apply their recently gained information in the process of knowledge acquisition with their friends or networks (Naidoo, 2021).

With the flipping of a classroom and digitalization of information, it establishes an active climate for learners to develop significant skills, team up with peers in instructional methods and participate in functioning and knowledge formation networks. Lopez-Perez et al. (2018) have distinguished six primary segments which ought to be found in a digital classroom. These segments incorporate learner gadgets, teacher gadgets, networks that enhance communication, a class sharing screen, servers and access to connectivity.

There have been significant studies which outline the benefits of teaching and learning with ICT or advanced digital instruction. Hutchison and Reinking (2011) in six quantitative studies reviewed came up with the following findings:

1. ICT when used in teaching and learning improves performance in the following reviewed subjects, English, Science and Mathematics.
2. There is a positive impact on learner attainment.
3. There is a positive association of Organization for Economic Co-operation and Development (OECD) countries between the length of time of ICT usage and learner attainment in Programme for International Student Assessment (PISA) Mathematics.
4. There is more rapid increase of performance for schools with high e-maturity levels.
5. Highly resourced schools obtain better results than schools with poor ICT resources.

The findings above are in line with the British Education Communication and Technology Agency (BECTA) (2006) who concluded that technology improves learner performance, enhances learning standards and assists in personalised and differentiated learning.

Poudel (2015) also concluded his study on the use of ICT that images assist in memory improvement of learners and complex concepts are easily explained to enhance comprehension. Raja and Nagasubramani (2018) note that visual images create a strong appeal in comparison to plain words. This is enhanced by use of visual aids from projectors and interactive white boards.

Nicholas and Ng (2012) found that mobile technologies have a positive effect on learner involvement in the process of learning and improves learning motivation. Balanskat et al. (2006) classify the following findings in a study conducted among European schools:

- Eighty-six percent of educators indicated that ICT has improved learner motivation and learner conduct.
- They further assert that it allows for independent learning and gives room for differentiation to address all learning abilities of learners.
- It accommodates all learning styles especially in mixed classrooms and learners take much responsibility in their learning processes (Devi & Nagasubramani, 2018).

Kumar and Kumara (2018) says it improves collaborative and cooperative learning in project work for both educators and learners. Embedding ICT classroom teaching and learning improves quality of activities and a variety of learning strategies (Balanskat et al., 2006) and it enhances cooperation and interaction among learners and teachers regardless of the distance or intercultural engagements.

A number of scholars reviewed above have reiterated a number of observable benefits of ICT towards teaching and learning. There are however scholars who have found contrary findings of the integration of ICT into teaching and learning. The following literature investigates challenges experienced in the integration of ICT strategies into teaching and learning.

Devi and Nagasubramani (2018) discuss the challenges teachers face because of the rapid inception of Information technology in teaching and learning. The cutting-edge advances request that teachers figure out how to utilize these innovations in their teaching and learning. These new technological innovations force the teachers' preparation needs. Gressard and Loyd (1985) stated that teachers’ attitudes towards technology is a critical variable in the effective execution of ICT in teaching and learning. They called attention to the fact that teachers don't generally have positive perspectives towards technology and their helpless mentalities or lack of know-how may lead to an inadequate use of technological activities.

Additionally, the most regularly referred to boundaries as noted by Kumar and Kumara (2018) are:

- absence of time to plan and link the digital work with classroom strategies,
- absence of access and connectivity in poor areas,
- absence of assets and digital resources especially in developing countries,
- absence of ability and know-how.
- lack of help from policy makers.

Another challenge cited by Butler and Sellbom (2002) and Chizmar and Williams (2001) is reliability and quality. This includes equipment, misleading data either at home or school, poor or slow connection availability and out of date technological resources.

Despite the above challenges, the above review has established that ICT technologies can improve teaching.

## 2.3 TEACHING LOW ABILITY LEARNERS' MATHEMATICS WITH ICT

Thomas and Edson (2018) indicate that teaching and learning Mathematics can be transformed by technology. They looked at the historic way of using calculators, computer programming, dynamic geometry and computer algebra systems (Ruthven et al., 2008).

The era of passive listening to Mathematics through lectures has been argued to achieve inadequate outcomes (Evans & Swan, 2014). The active involvement of learners which is brought about by the integration of technological strategies in the teaching and learning of Mathematics has yielded positive results (Pellegrini et al., 2018).

The emerging of learners with varying abilities in a streamed class based on their mathematical ability, created a challenge for the teachers to come up with support strategies to accommodate all (Othman et al., 2016). It is therefore required that an educator must be flexible in their teaching strategies and modify their content delivery modes to accommodate all learners' abilities to comprehend information especially in the Mathematics curriculum (Subban, 2007).

Low ability learners battle with learning and carry different barriers to the classroom and teachers work hard to discover proper approaches to help them succeed (Reddy et al., 2016). Technology and innovation are turning out to be more perceived as a substitute strategy for instructing and supporting learning (Mazana et al., 2019).

Teaching low ability learners Mathematics using ICTs has the potential to yield better results when linking the students' ability with their learning preferences (Sternberg & Grigorenko, 2002). Various applications offered by computers act as extra support that has the potential to assist low ability learners. The teaching of Mathematics with computers has evolved over time due to the smart and powerful applications their operations provide. These include coding, data compression, fractals, cryptography and computational geometry (Oldknow & Taylor, 2008). The new advanced skills such as modelling, doing estimates, validations and acquiring data are becoming quite common in the digital age (Subban, 2006).

In his analysis Zengin (2017), citing Niess 2005, Freudenthal (1973), and Mazana, et al. (2019), indicates that the progression of ICTs over the decades has also created changes in the education field particularly in Mathematics and Science subjects, making comprehension of difficult concepts in Mathematics a little easier. They indicate that the colour, the sound and the live demonstrations make complex topics easier to comprehend by lower ability learners.

Yadav et al. (2018) in their study of the use of computer apps in teaching Mathematics, both pre- and post-tests indicated that using Mathematical applications has the potential to increase learner attainment levels for various learner abilities and minimizes the gap between high and low ability learners.

In applying what Valiande and Tarman (2011) call differentiated learning of Mathematics using various teaching modes such as digital learning platforms, they could improve learner attainment if they are suitable for the learners they are preparing for. These differentiations take into consideration learners' level of comprehension, the type of knowledge suitable for such a learner and learning becomes more learner orientated. The importance of learning Mathematics has been echoed and the role of Mathematics in everyday life cannot be ignored (Yadav et al., 2018).

As indicated by Widakdo (2017), mastery of Mathematics is a tool to function in the fourth industrialization era even for low ability learners.  A number of countries have put in a lot of resources in the Mathematics classrooms including introduction of computers to try to assist learners in Mathematics mastery (Yadav et al., 2018).

Some of the benefits of utilizing technology with low ability learners are increased inspiration, individualized directions and opportunities to work in their own particular manner (Yadav et al., 2018). ICT learning can give prompt input, independent learning and individualized exercises. Discoveries demonstrated that learners have expanded confidence and are more energetic towards school when working with technology (Raja & Nagasubramani, 2018). This elective way to deal with educating low ability learners has demonstrated improvement in participation, accomplishment and conduct (Waxman & Padron, 1995). It is further noted that learners discover that ICTs give exact and prompt feedback to their work; in this manner mitigating the educator of that job. Learner and teacher connections, and learner-to-learner associations, change to one of help and cooperation (Ambroz & Bukovec, 2017).

In conclusion, technology offers advanced learning conditions, which are of benefit to low ability learners. There are however a number of challenges which need to be addressed for technology to bear the expected outcomes especially for low ability learners, but the benefits outweigh the challenges (Kumar & Kumara, 2018). Issues around the availability of hardware (Ambroz & Bukovec, 2017), issues of educator competence and change in pedagogy, (Valiande & Tarman (2011) and issues around learner willingness still need to be explored. Despite these challenges, there are however a number of countries especially Asian countries whose ICT and non-ICT strategies have yielded far reaching results in the international benchmark assessments.

The following subsection investigates a number of well performing countries globally in Mathematics as per the international assessment benchmarks, and the strategies to improve Mathematics performance.

## 2.4 THE WORLD VIEW ON MATHEMATICS

### 2.4.1 INTRODUCTION

Schooling is compulsory in all countries with various opportunities and facilities offered differently, with Mathematics being a central subject in primary school. According to Simms et al. (2017), achievement in Mathematics denotes a success in the academic field, guarantees future employment and economic productivity (Bussi et al., 2017). “Mathematics is a language that represents a series of meaningful statements that we want to convey. Mathematics is required by all scientific disciplines to increase the predictability and control of the science. Besides being a language, Mathematics also serves as a tool of thought in drawing a conclusion by using a mind-set” (Purba et al., 2017, p. 73).

In recent years, several countries have invested both time and finances to come up with effective interventions to improve Mathematical attainment. Several key contributors have been identified, as general comprehension of Mathematical concepts inhibits control (Cragg & Gilmore, 2014), counting skills and general learners and educators’ attitudes (Maloney et al., 2013).

Worldwide, countries' educational policies differ when it comes to ways to teach and assess Mathematics. Some countries place more emphasis on summative assessment as a benchmark for their learner promotion while some still opt for formative assessment or social promotion. However, there are standardized benchmark tests which portray each country's Mathematics, Science or language level in which a number of countries participate. One of such international benchmark tests is Programme of International Students Assessment (PISA).

According to the results of PISA from 2000 to 2018 as indicated in Figure 2.1 below, Singapore has consistently been the highest performer for several years during which the study was conducted. Singapore learners took part in the Trends in International Mathematics and Science Studies, and they continue to rank among the top performing learners globally. Singapore's fourth and eighth grade learners scored first in Mathematics in the years 1995, 1999, 2003, 2015. This is an achievement recognised worldwide.

In another examination PISA (Program for International Student Appraisal), found that among 15-year-old learners, Singapore positioned first in 2015 and second in 2009 and 2012 (Kaur & Lee, 2017). The following is an outline of Singapore's Mathematics strategies.

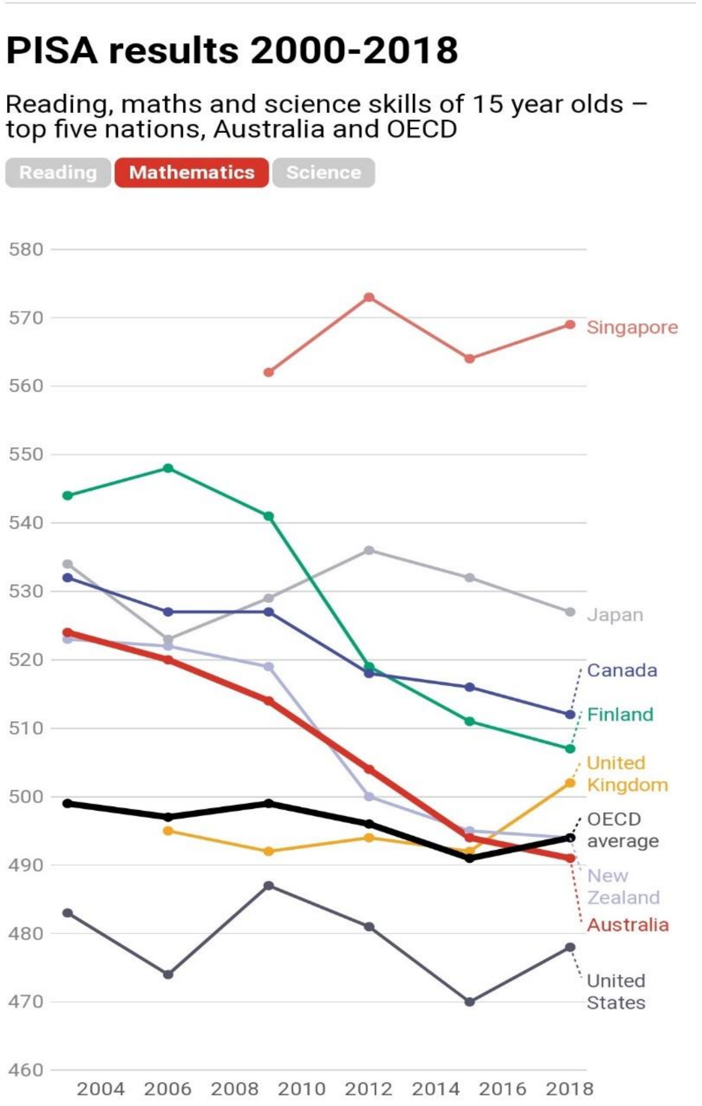



**Figure 2.1 (Programme of International Students Assessment) PISA Results 2000-2018**

### 2.4.2 SINGAPORE

The findings of an early TIMSS study in Singapore led to many curriculum changes; the content was decreased by about 30% (Kaur & Lee, 2017) and problem-solving changed into the most critical objective of Mathematics learning. The content is presented as abilities and processes, while attitudes reflect the affective aspects of learning. The importance of self-regulation is illustrated by metacognition and processes involve the development and application of Mathematical knowledge.

Figure 2.2 below outlines the Singapore Mathematics Framework. In this frame, the Ministry of Education has elaborated the concepts, perspectives, metacognition and steps required for critical thinking. From the period 2013, critical thinking abilities, heuristics and applications became a huge part of the learning process.

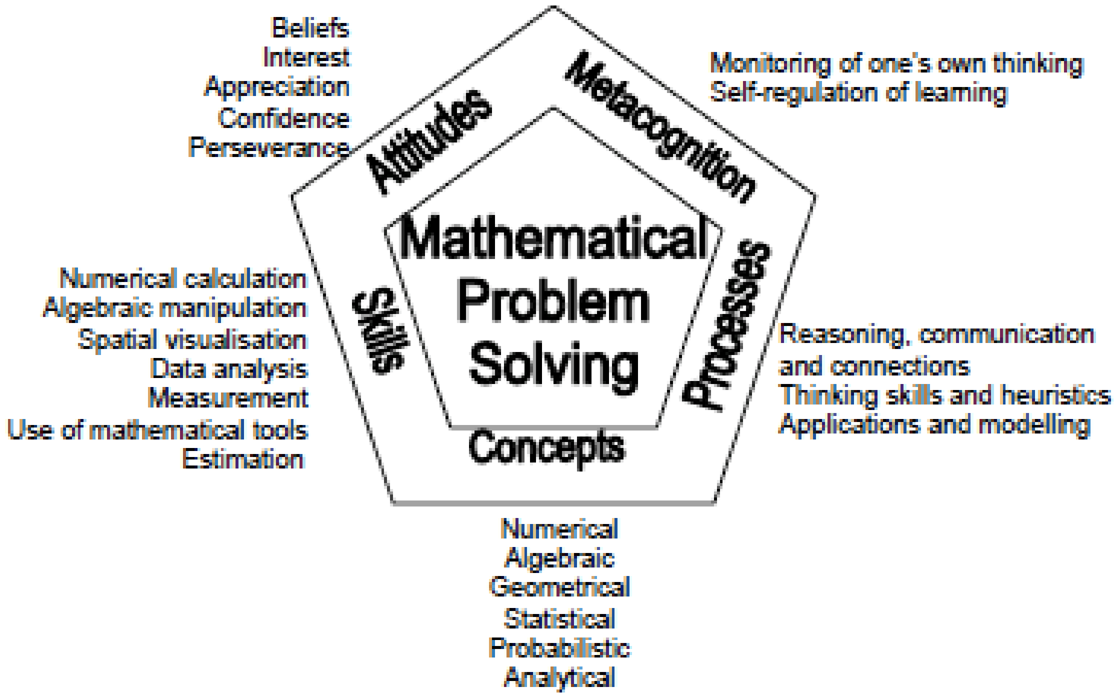



**Figure 2.2 Mathematics framework from the Singapore Mathematics curriculum (Kaur & Lee, 2017)**

The focal point of the educational curriculum since 1992 was critical thinking. Kaur and Lee, (2017) diagram a negligible usage in classes with study materials commonly containing routine issues and guidance in arithmetic exercises. Because of the restricted execution of critical thinking by educators, assessments have as of late contained novel, non-routine methods. Teachers are currently being faced with new difficulties to plan and utilize comparable assignments in their exercises. What's more, two new activities “Thinking School, Learning Country” (TSLN) and “Show Less, find out More” (TLLM) have planned to diminish the educational program content further and encourage learners into really thinking and critical problem-solving skills (Kaur & Lee, 2017). The Singapore Mathematics strategy is centred on mastery of concepts, which is accomplished through purposeful sequencing of ideas. Some of the important aspects incorporate the CPA (Concrete, Pictorial, Abstract) progression, number bonds, bar modelling and mental math. Rather than pushing through repetition and memorizing, learners' study how to critically think and comprehend core Mathematical methodologies (Visser et al., 2015).

Not only did Singapore rework their curriculum, but they also made visible changes in the application of ICT in the teaching and learning of Mathematics throughout the years. The following is a brief outline of the ICT technological strategies employed in Singapore and their impact.

In the 1970s Singapore was very active in promoting the correct application of technology in the daily activities guided by their six National Information Technology (IT) plans. Guided by this background, this saw the birth of the National Information Communication Technology Masterplans as one of the reforms (Tabach & Trgalova, 2017). The ICT infrastructure, educator training and implementation strategies were put into place and ICT skills were developed both at primary and secondary level (Yuen & Hew, 2018).

Since the 1980s to mid1996, there were various strategies which promoted the use of ICT in all schools. With their realism ideology in education (Tan, 2010), which was highly criticized (Natarajan & Laxman, 2021), Singapore came up with education policies and ideologies such as Thinking Schools and Learning Nations which enhanced critical thinking among Singapore learners. Their curriculum became more inquiry based (Tabach & Trgalova, 2017).

"One of the key responses was the introduction of Information Technology which would lay the basis for new teaching and learning practices and innovation," (Natarajan & Luxman, 2021, p.3). The then Prime Minister of Singapore Mr Goh Chok Tong believed that integrating ICT into education could improve learners' digital skills and change their school's learning experiences and grow them into efficient citizens (Kaur, 2014). Singapore introduced four ICT Master Plans in education throughout the last two decades. The core focus according to Reyes and Gopinathan (2015) was to reduce the content within their curriculum, bring in critical thinking skills within their curriculum and reinforce ICT strategies in schools to support teaching and learning.

According to Ndaruhutse et al. (2020) Singapore's Masterplan 1 was launched in 1997 and focused on building technological capacity in schools and capacitate the teacher for roll out and use of ICT. In 2002 Singapore was number two after Finland in the Global competitiveness report (2001-2002) for the accessibility of internet in schools (Yuen & Hew, 2018).

The second masterplan came into practice in 2003-2008, which focused mostly on improving exploration and innovation within teaching and learning new teaching pedagogies, such as inquiry-based learning and problem-based methods of teaching and learning (Lee et al., 2019). The new methods and ICT aligned products such as e-portfolios, videos, animations and blogs emerged. These platforms occurred as socio-technological initiatives such as You-tube and Wikipedia were also becoming popular (Natarajan & Laxman, 2021).

The third masterplan started in 2009. These were strategies to integrate ICT, teaching methods and assessment into the Singapore curriculum. As explained by (Natarajan and Laxman, 2021) the aim was to encourage and instill higher order thinking, communication and collaboration skills in the education system. In 2014 educational strategies such as Fastrack at school, Edvantange and Edulab were introduced and assessed (Natarajan & Laxman, 2021).

The Masterplan 4 for ICT in the Education basically aimed at strengthening and building towards ensuring that ICT is infused in the curriculum design and development and to offer appropriate resources to enhance online learning, include ICT in assessing learners and support and increase digital learning and media literacy (Lee et al., 2019).

The results of these significant changes in Singapore are a result of a journey it took to transform the education system from a struggling one to the one currently hailed as the best, most effective and successful worldwide (Lee, et al., 2019). Another Asian country which prides itself in good Mathematics performance is China. The following analysis will look at Hong Kong Mathematical performance and their strategies.

### 2.4.3 HONG KONG

In his introduction at a discussion coordinated by the Public Educational plan Board, Adamson et al. (2017) indicated that Hong Kong has gone through huge changes since 2000 with an emphasis on learners learning through arrangement of the educational programme, teaching methods and evaluation.

Related to this change are the accompanying key standards:

- all learners have freedom to learn and ought not to be screened outright on time,
- long lasting learning capacities are required for a contemporary and future world,
- entire individual advancement for improving personal satisfaction in the public arena, culture, economy,
- originations of information changing – cross disciplinary, individual, co-built,
- primary changes to encourage openings and pathways for every single youngster (Adamson et al., 2017).

Figure 2.3 below indicates the Mathematics curriculum structure in Hong Kong. Adamson et al., (2017) indicates that the Hong Kong core curricular pedagogy focuses on how learners learn, and teachers teach. It aligns its curriculum on what is worth learning and its pedagogy on learners' learning styles.

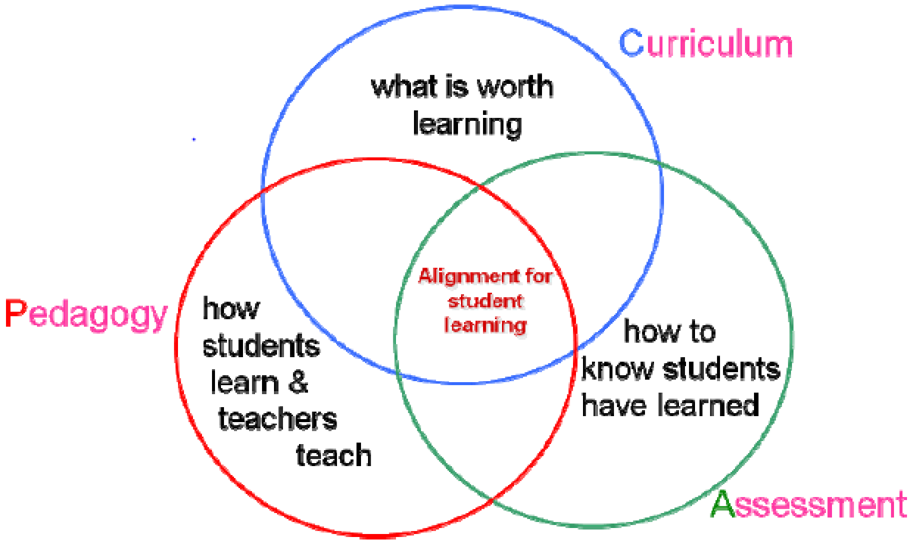



**Figure 2.3 Aligning curriculum, pedagogy and assessment in Hong Kong (Adamson et al., 2017)**

The Hong Kong Educational program structure has three linked elements: key learning regions, non-exclusive abilities and qualities and mentalities. Mathematics is among the most critical learning areas and the generic abilities include joint effort, correspondence, inventiveness, basic reasoning, data innovation, numeracy, critical thinking, self-administration and study abilities (Adamson et al., 2017). While Hong Kong has a lucid educational plan with exclusive requirements, which esteems acquiring and preparing essential abilities and major ideas, with teachers who have great academic substance information, Adamson et al., (2017) recognize that learners have low self-efficacy and negative mentalities, especially in Mathematics. In addition, there is an assessment direction, the math educational program is thick and conservative, and the instructing and learning is surged.

Teachers in Hong Kong are more mindful of critical thinking ways to deal with presenting arithmetic, yet there remains restricted proof of execution. The teachers draw learners into the conversation, numerical thinking and critical thinking. They keep on driving learners on a foreordained arrangement pathway instead of permitting more open examination and investigation of numerical thoughts (Fung et al., 2017). Perceptions in Year 1 classes were described as "entire class teacher people engagement and profoundly organized in group pair work" (Fung et al., 2017). Even more of late, Fung, et al. (2017) noted little utilization of gathering work or open-finished inquiries, reasonable for exploratory critical thinking in the exercises of Hong Kong secondary teachers.

Just like Singapore, Hong Kong also embarked on technological innovations in their teaching and learning process. The following is a discussion of the ICT teaching and learning strategies in Hong Kong and their impact towards teaching and learning.

In the late 1990s, Hong Kong's society looked at E-learning as a vital component as part of their education reform at their schools. It has viewed Information Technology as a component of interactive learning as one of the four activities (stages) highlighted in the curriculum change (Pepin et al., 2017).

The first stage which took place from 1998 to 2003 was the introduction of a technological infrastructure with Hong Kong schools, educator training on ICT, setting of ICT standards and obtaining a community involvement to enhance ICT home learning (Hao, 2018).

The second stage which began in 2004 to 2007 was empowering teaching and learning through technology. This second strategy focused on the technical and pedagogical aspects of literacy framework and ethical use of ICT in daily life (Yuen & Hew, 2018). The third stage which focused on the theme "right technology at the right time for the right task" (Chantaravisoot, 2017, p.1474) started in 2008 to 2013. Its purpose was to create online curriculum-based resources which are digital. The strategy focused on the integration of ICT into learning to improve learner performance (Yuen & Hew, 2018). It further developed E-resources such as textbooks for both Mathematics, Science and literacy.

With the advocacy of STEM education (Chantaravisoot, 2017), Hong Kong strives to attain the following in their education system:

- competitiveness in innovation in Mathematics, Science and Technology,
- to encourage hands-on learning which enhances the concept of integration and application of their learning knowledge.

Yuen and Hew (2018) has further argued that the benefits of ICT integration and re-introduction of STEM in Hong Kong education has far-reaching results to improve learner attainment. The significance of STEM is to augment learners' learning through the inclusion of activities which put into place 21$^{st}$-century skills (Bureau of Education, 2020).

Like Singapore and Hong Kong, another Asian country which performs well in the TIMSS assessment is Japan.

### 2.4.4 JAPAN

Japan is the third Asian country with the highest performance in the international benchmark. Japan introduced a Knowledge Construction with Technology spearheaded by the Consortium for Renovating Education of the Future (CoREF) in 2010. The objective was to transform old teaching methods to more collaborative and knowledge creation methods. The learning outcomes which were targeted for both primary and secondary learners were to promote collaboration, problem-solving skills using Knowledge Construction Jigsaw pedagogy (Chantaravisoot, 2017). Japan's curriculum focuses mostly on formative assessment using various technologies and their learning is more learner centered with a teacher only facilitating discussions (Yuen & Hew, 2018).

To ensure high performance in Mathematics, the use of the following was employed in Japan. As described by Yuen and Hew (2018), within the basic educational ideology, the curriculum was based on numeracy and literacy improvement skills and in the knowledge and deepening structures; the curriculum put more emphasis on the comprehension of vital ideas in and across various subjects and their applicability towards solving real world issues. In his lecture Professor Ikeda on Japanese education in JICA KCCP, indicated that in Japan high schools, both attendance and test scores are used for the judgement. So, if one's score is very low, the teacher usually gives him/her a chance to take another supplementary test. In some cases, a learner may take a test more than once (until the result gets satisfactory) and drop-out or repeating in high schools is very low, but it is not zero.

According to Tan, (2019) Japan is one of the countries which is technologically advanced even within their education sector. ICT basically is employed to enhance and support collaborative programmes and link learners and educators out of school bonds. Using simulations and digital resources, learners are supported to comprehend linked or related aspects, explore ideas and problem-solving skills. Within a knowledge creation thinking model, the curriculum is basically structured so that it enhances inquiry skills, creative and critical thinking skills (Tan, 2019). Japan places more emphasis on formative assessment as opposed to a summative assessment and it is one of the countries which still employ social promotion policy (Pepin & Gueudet, 2020).

Japan also uses a model, whereby learners are encouraged to apply alternative solutions and the educator's pedagogy has shifted into a more hands-on classroom. According to Evans and Swan (2014) Japan's lessons are aligned into four components which are:

- Hatsumon where the teacher initiates a class discussion by giving learners a problem,

- Kikan-Shido which encourages group work and collaborative learning,
- Neriage where a class discuss their various findings and strategies used,
- Matome which is a summary of all possible solutions and various strategies used to reach a solution.

The Japanese ideology of learning has influenced a number of scholars. “The emphasis is the importance of looking at learners’ feedback towards tasks which are difficulty, strict monitoring of learner’s work discerning the Mathematical value of alternative approach in order to scaffold learning”, and assessment for learning instead of assessment of learning (Evans & Swan, 2014, p. 4).

### 2.4.5 AUSTRALIA

Another interesting review was done in Australia, as its performance has been reviewed by a number of scholars in the international tests as that which is not as per their expectation (Karp, 2019). According to Sa’ad et al. (2014) Mathematical low performance has become a worldwide concern. The level of Mathematics in Australian schools is a widely shared concern. All stakeholders are concerned about why a wealthy country, ranking second on the United Nations’ Human Development Index, is dropping in the global education rankings. There is visible evidence of the decline of Mathematics in the NAPLAN (the National Assessment Program – Literacy and Numeracy), TIMSS (the Trends in International Mathematics and Science Study), and PISA (the Programme for International Student Assessment) but the government is putting more resources into the education system (Thomson et al., 2021).

Trends in International Mathematics and Science study (TIMSS) is conducted every four years since its inception in 1995. In 2018, 580000 learners from 64 countries sat for this benchmark assessment, this included 14, 950 learners from Australia (Karp, 2019). According to Walker (2021), the 2018 PISA indicated a decline among the Australian learners’ achievements in Mathematics, in comparison to the OECD average showing that 23 countries obtained a higher score in Mathematics, compared to Australia and this downward trend has been long term as indicated in the figure below.

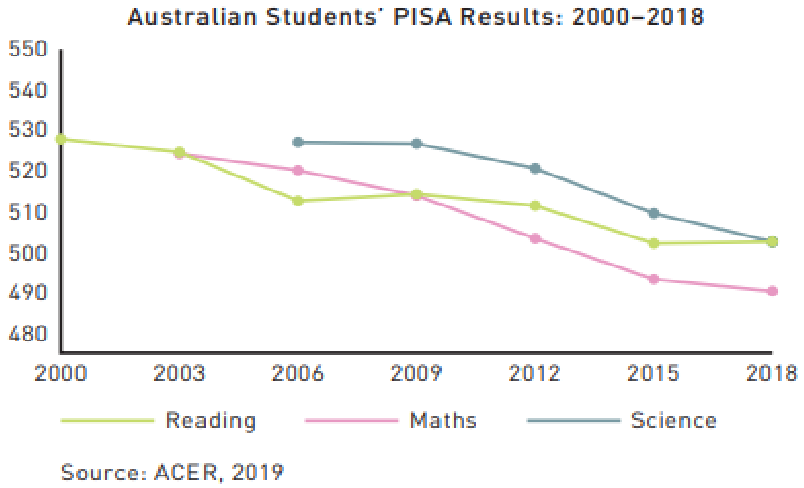



**Figure 2.4 Australian students' PISA Results 2000-2018 (Walker, 2021)**

Although the Year 8 achievement in Mathematics relatively indicates some improvement, Walker (2021) argues that the Year 4 attainment of learners remained unchanged since 2007. (Thomson et al., 2021) argues that learners from Australia obtained 68-78% in comparison to the higher performing countries such as Singapore in the TIMSS intermediate international benchmark.

In her analysis in a study conducted among the Australian teachers, Walker (2021) found the biggest gap observed by teachers in the survey which investigated the students' transition from primary to secondary school, almost all teachers believe that the gap identified in Year 7 will have a negative effect on students' performance in Year 8. The following are barriers teachers experience due to teaching both high ability and low ability learners in the same class as outlined in a study conducted by Walker (2021):

- A need to differentiate more widely has led to more preparation time.
- A need to get engaging, quality work that suits the learners' ability level.
- More differentiation in pedagogical practice is needed.
- The large range of abilities in class makes it difficult to cater for everyone.
- There is a large divide between those who already have good skills and those who do not.

In Australia, there has been a robust change in educational methodologies that were presented to the teachers (Peter-Koop & Luken, 2017) within the national curriculum statement. There was pre-service and in-service training, which were aimed at changing the existing traditional curriculum delivery into a more modern and reformed teaching approach that included digital and remote learning (Peter-Koop & Luken, 2017). This has seen a drastic improvement in learners' attainment in TIMSS.

Australia's intervention strategy to support vulnerable learners is called Extending Mathematical Understanding (EMU). This approach in the year following the intervention about 40% of the learners had improved significantly (Gervasoni, 2018). In Australia early identification of learners with learning barriers in Mathematics is done and are enrolled into Mathematics support programmes (Peter-Koop & Luken, 2017).

Learners' barriers are classified into two categories. Firstly, there are learners who are medically challenged, and the second group are learners with low Mathematical performance due to lack of exposure to learning quality Mathematics in an environment which enables them to excel in the subject (Gervasoni et al., 2021).

The EMU strategies and principles indicate that all learners obtain high quality education in Mathematics in their schools which allows them to excel with appropriate resources and support (Hemmi & Ryve, 2015). The EMU is built on the social constructivist approach to learning where teachers focus on creating learning environments which are rich and accommodate different learning abilities and understand how various learners learn Mathematics (Scherer et al, 2017).

According to Gervasoni et al., 2021), the EMU strategies advocate peer teaching, coaching and small group teaching during Mathematics lessons. There are three levels of support, the first offers educators' strategies on how to best advance a learners' Mathematics acquisition. Learners have individual learning plans which stipulate goals of learning and practices which may best advance learning (Widjaja et al., 2021).

Hansen (2017) indicates that the level two offers the first support together with classroom support, peer learning, collaborative learning and coaching.  Level three further adds level one, two and the in-service training of educators on remedial programmes which is a 36-hour course which focuses on assessment of children's knowledge, characters, teaching methods and instructional designs which fully support Mathematical learning. Australia does not only rely on the non-technological interventions to improve their learner's performance, but they have also invested time and resources in the digital innovations to assist in the teaching and learning processes.

Qayyum and Zawacki-Richter (2018) state that in the Australian curriculum, learners use Information and Communication Technology (ICT) capacity as they figure out how to utilize ICT adequately and fittingly to get to, create and disseminate information, deal with concepts and work together in all learning aspects at school and in their lives beyond schooling. ICT capacity includes learners figuring out how to capitalize on the advanced innovations accessible to them, adjusting and employing better approaches for studying using technology.

Many learners are growing up with technology and innovation as a daily part of their lives. Data and correspondence innovation (ICT) in the Australian education, outlines the way in which technology is utilized in the world, and intends to assist learners with utilizing technology to upgrade their performance both at school and at home. They learn to create and apply these significant abilities socially and morally in the learning spheres (Slee, 2018).

To conclude, Walker (2021) indicates that, although there are systems in place to improve Mathematical attainment in Australia, there are still a number of challenges in the curriculum which needs to be addressed over time in order to attain a better result in Mathematics.

### 2.4.6 ENGLAND

In England, the new Curriculum Mathematics documentation for Key Stage 3 and Key Stage 4 (the beginning four years of secondary education) are less prescriptive, enabling teachers to have more flexibility. They have a personalised teaching, learning and thinking skills system and are based on learning evaluation. Problem-solving is described as "at the heart of mathematics" (Parker & Levinson, 2018), and is presented as a process involving representation, analysis, assessment and communicating and reflecting. The explanation for the relationships depicted in Figure 2.4 is “the diagram represents the dual nature of Mathematics; it is both a tool for solving problems in a wide range of contexts and a discipline with a distinctive and rigorous structure” (Parker & Levinson, 2018).

Figure 2.5 below is an outline of the England Mathematics learning model. There is a link on procedures, concepts, analysis and critical thinking which is presented to and by learners (Parker & Levison, 2018).

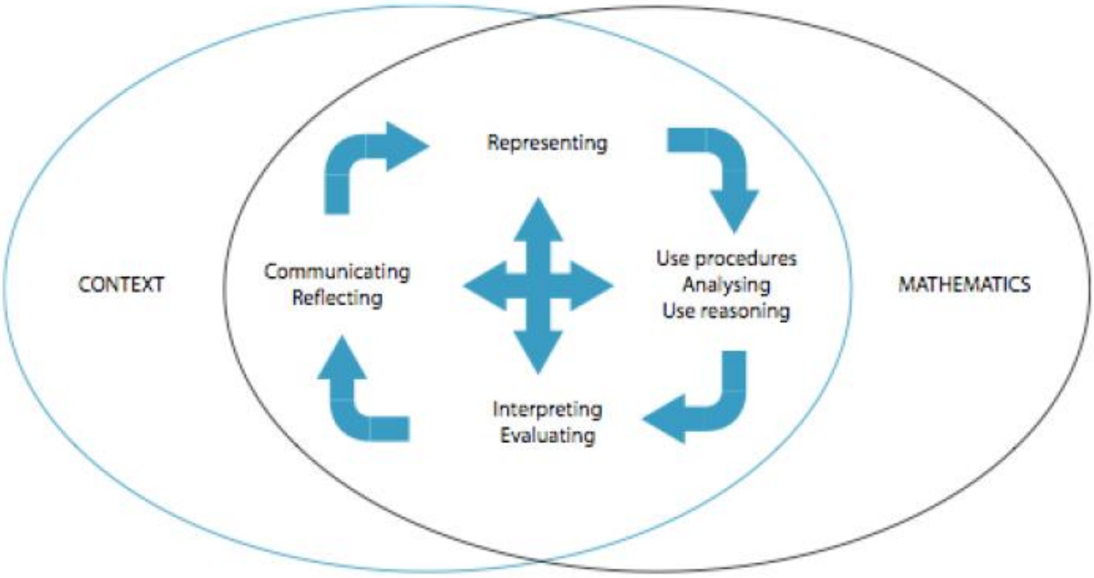



**Figure 2.5 A representation of the processes involved in problem solving (Parker & Levinson, 2018)**

To support teachers, a diverse array of supporting material was prepared with examples of problems and rich activities for each of the content strands for school and district professional growth (Parker & Levinson, 2018). Noyes (2007) notes that tteachers are encouraged to examine the process and their pedagogies, trying to incorporate modern methods and technologies, which allow for remote engagements. This helped teachers immensely to incorporate the digital processes into the lessons and provide the students with daily problems. As stated by Parker and Levinson (2018), the benefits were however determined through the continuous results analysis, and through international curriculum related examinations such as TIMSS. The strategy was further changed to allow for the new assessment items, which will also be changed to include more open-ended questions.

Figure 2.6 below is a model that describes the process involved in the teaching and learning of Mathematics, using a hundred chart as a reference point. As explained by Parker and Levison (2018), learners should be able to analyse, interpret and evaluate and reason out procedures as they present their findings.

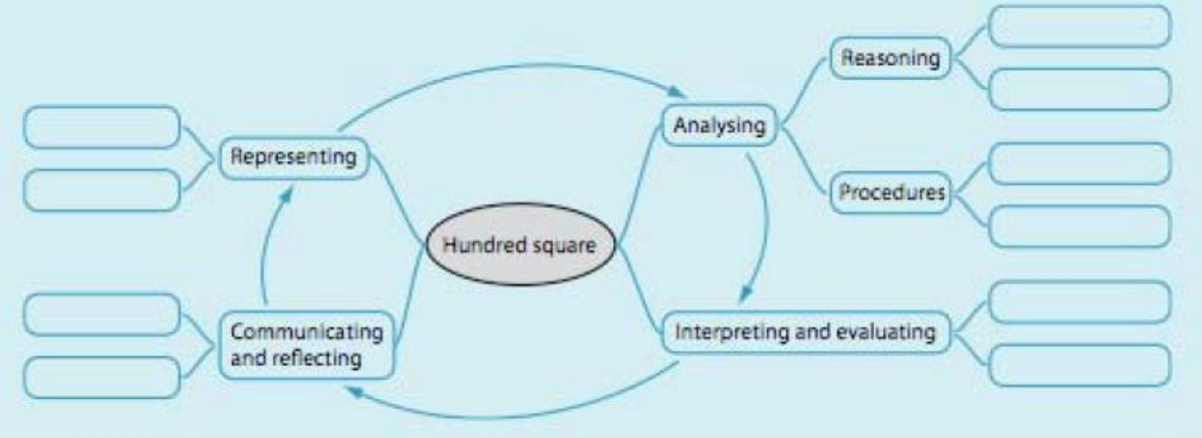



**Figure 2.6 Template to aid teacher identification of processes in a task involving a hundred chart (Parker & Levinson, 2018)**

Like the other previously technologically advanced countries, England also uses technology to assist and support teaching their learners. England uses the frameworks of communities of inquiry and collaborative design (Lavicza, 2010).

### 2.4.7 USA

The 2017 National Assessment of Educational Progress (NAEP; National Center for Educational Statistics [NCES], 2018) recorded Mathematics scores for U.S. fourth graders having improved from 1990 to 2000 in all grades. But, as of 2003 to 2017, attainment scores have been low, with an average of 40% attained in 2017. It is alarming to discover that the variance in Mathematics attainment has never changed since the 90s (Pellegrini et al., 2018).

In 2017, in the United States, white students attained a 57%, while African Americans obtained a 19%, Hispanics scored a 26%, and 24% of Native Americans scored in contrast to the Asian-American students who attained 67% average in Mathematics assessment (Pellegrini et al., 2018). This places minority groups as mostly low ability learners in Mathematics in these communities.

According to Stein and Kaufam (2010) there has been a significant financial resource invested to improve the elementary Mathematics, using instructional technologies and non-technological reforms aimed at improving performance of minority groups and looking at the significance of Mathematics and the socio and economic impact it poses on ethnicity, social class and gender gaps. The 2015 report as outlined by Pellegrini et al. (2018). Every Student Succeeds Act (ESSA) recognized the impact and effectiveness of Mathematical interventions which are aimed at improving attainment and to minimize achievement gaps.

Several reviews on elementary Mathematics programmes have been published in recent years. In his review of A Nation at Risk article for United States, Lynch (2017) indicates that learner grade movement should be based on the ability to master content learnt in the specific grade. This was influenced by the Clinton 1998 administration which called to end social promotion in the American states. This was followed by many states passing legislation which denied social promotion (Lynch, 2017).

Pellegrini et al. (2018) acknowledged 87 rigorous studies conducted by Slavin and Lake (2008) of results of elementary Mathematics initiatives and concluded that learners' attainment is most positively affected by Mathematics strategies which incorporate collaborative learning, individualized activities, effective classroom management, inspiration, and tutoring.

In their studies, Lynch (2017) and Pellegrini et al. (2018) scrutinized the effectiveness of Mathematics interventions in grades K-6 using 40 studies. These studies reported that personalized interventions which differentiate learners had a more significant effect in Mathematical attainment than whole-class programmes.

Savelsbergh et al. (2016) conducted a meta-analysis evaluating the impact of innovative Science and Mathematical strategies on learner attainment from grade one to twelve. For Mathematics, a total of 19 studies were included revealing that Mathematical interventions which are learner specific have a positive impact. Furthermore, all studies indicated the following findings as impactful strategies towards improved learning for low ability learners: "Context-text based teaching, inquiry-based learning, a technology-rich learning environment and collaborative learning are the four types of educational techniques identified by the authors as effective in enhancing and supporting learning" (Pellegrini et al., 2018, p.5). Two more studies looked at the impact of technology-based programmes in elementary and secondary schools (Pellegrini et al., 2018). It was concluded by these studies that computer technology has an ability to impact learning in a constructivist classroom. Savelsbergh et al. (2016) took note of 46 studies and discovered that when computer technology is integrated with a constructivist teaching method, it has a greater effect.

Cheung and Slavin (2013) found 45 thorough studies on technology applications in Mathematics conducted in elementary schools and identified three types: computer-management learning, comprehensive models, and supplemental, computer-assisted instruction (CAI) technology. With a mean magnitude of +0.18, supplemental CAI has the highest effect on Mathematics success as indicated in Pellegrini et al. (2018).

Formative Assessment Lessons (FALs) were designed to assist US high schools in the implementation of the new common core state standards for Mathematics. A third of lessons tackled non-routine, problem-solving tasks and their objective is to enhance a learner's ability to apply Mathematics mastery to problems which are unstructured either in pure Mathematics or the real world (Ariyanti & Hermita, 2020). USA shifted from a traditional classroom whereby an educator exposes learners to a certain technique and learners are supposed to practise with given examples.

US shifted from this model of learning Mathematics using comprehension, criticizing, comparison and discussion of a number of approaches to solve a problem (Fede et al., 2013).

### 2.4.8 CANADA

In a study conducted by Deppeler et al. (2015), most Canadian provinces, except for two, indicated a statistical decline in Mathematical performance in examinations, which were conducted internationally by the Organization for Economic Cooperation and Development. In their analysis of various provinces, most learners performed at the minimum in Mathematics indicating that quite a significant number of students are struggling in Mathematics (Deppeler et al., 2015).

To solve these challenges, Canada adopted discovery based instructional learning styles within their classrooms. These strategies are similar to Johnson & Mayer (2009) enquiry-based instruction and Deppeler et al. (2015) experiential learning and constructivist learning adopted in American schools. These strategies consist of:

- Teaching must be learner centred; an educator must offer an explicit explanation which will promote minimal guidance.
- Offer open-ended challenges with numerous solutions.
- Application of concrete objects as teaching aids such as blocks and drawn pictures.
- Varying student-centred methods.
- Reduce the use of worksheets.
- Mathematics must be an applied subject instead of using memorization methods.
- Typical applications like column addition or long division are moderated.
- A top-down approach in which students work on complex problems.
- Starting from simple to complex methods of approach in problem-solving to be encouraged.

The same intervention strategies were adopted in Nigeria and Kenya (Ekwueme et al., 2015), due to the declining Mathematical performance of the learners in lower primary schools. The learning where learners are at the centre of teaching and learning and discover their own knowledge with minimal educator guidance, was advocated. This implies that learners were awarded an opportunity to manipulate objects such as Mathematical sets, measuring instruments and actual shapes, making learners active participants and not passive observers. This implies that learners' preferred learning styles were put into play to accommodate both high ability and low ability learners.

### 2.4.9 SUMMARY

The 2015 TIMSS report (Trends in International Mathematics and Science study, 2016) as outlined by Reddy et al. (2016) further reveals a significant improvement in performance for developing countries such as Russia, Kazakhstan and Northern Ireland in Mathematics and Science performance, but there is a visible gap between highest performing countries such as Singapore, Japan, United States, United Kingdom and Hong Kong. Further studies indicate that although the UK is among the higher performing countries, a large majority of learners in England are unable to achieve expected levels and Australia is also not performing to expectations in Mathematics (Simms et al., 2017). The poor early Mathematical acquisition skills have been regarded as contributing to the "vicious cycle of disadvantage and a poverty of opportunity" (Simms et al., 2017).

The world comparison studies like PISA (Organization of Economic Cooperation and Development, OECD, 2014) have shown the impact of the Mathematical skills of a country on economic growth and wellbeing (OECD, 2010). However there remains a critical gap between the US, UK and Singapore, the best performers on the planet (OECD, 2010).

The Mathematics curriculum and problem-solving initiatives of Singapore, Hong Kong, Japan, USA, England, Australia and Canada reveal some similarities and some differences. What is evident and similar among the countries reviewed, is the introduction of ICTs in the teaching pedagogies and the curriculum changes which were introduced. Singapore made a major change by decreasing Mathematical content to pay more attention to problem-solving concepts and develop deeper learning in Mathematics.

The RME approach in the Netherlands was designed to develop Mathematics learning from relevant problem contexts, and the new curriculum in England offers enhanced flexibility and examples of rich problem-solving activities, Japan introduced the hands-on approach, while Australia offers among its strategies a 36-hour in-service training for Australian teachers in remedial and support interventions and the same standards of teacher support have produced significant improvement in Mathematical attainment.

The above analysis of top performing countries in TIMSS indicates that all the countries have placed interventions in place to support Mathematical performance of low ability learners. Although assessment varies in these countries some are opting for the end of social promotion (USA) while others place less emphasis on summative assessment (Japan). Needless to say, there are measures in place to support low ability learners in the higher grades in Mathematics and Science subjects (Smith et al., 2018).

One can then summarise that different countries not only provide resources to improve Mathematical attainment but have devised support strategies and theories that could remedy this challenge, which are both digital and non-technological (Smith et al., 2018). Numerous possible solutions to this problematic area have been echoed by specialists in this field yet the problem continues. Sa'ad et al. (2014) further outlined that the answer offered cannot just be a theory on paper, but there is a requirement to implement, monitor and evaluate Mathematical performance worldwide. Countries can further learn from each other's best practices and reinforce their support strategies to improve Mathematical attainment.

Another significant similarity among the above reviewed countries is the high level of the ICT applications within the teaching and learning in these countries and it is fully structured and resourced (Gibson & Smith, 2018). There are policies guiding the application of ICT into schools (Savelsberg, 2016). Their curriculum is streamed so that it accommodates the implementation of ICT instruction in the class as echoed by Gervasoni et al., (2021) and Lynch (2017). There is a proper buy-in of all stake holders in the implementation process of ICT into education (Savelsberg et al., 2016). The government is involved in all the design and implementation as well as the monitoring of ICT implementation and non-ICT strategies to improve Mathematics (Lynch, 2017 & Gervasoni et al., 2021).

The introduction of ICTs in these countries saw the following changes: teaching and learning became inquiry based, learning became more individualized, learners learn through collaboration and interschool collaborations and international participations (Yuen & Hew, 2018). Lastly the objective of teaching and learning Mathematics was realized through the use of both ICT and non-ICT instructional strategies (Savelsberg et al., 2016).

The importance and significance of Mathematics has been echoed, Maths does not only permit societies to and offers them the capacity to control lives, especially in the digital era, but further offers knowledge with a solid foundation for real theories; it further promises societies improved economies (Steen, 2001). As indicated by Kahn (2001), in several schools, there are many learners who fail Mathematics because of various bad experiences. It is not uncommon to hear learners say that they hate Math. Novriani and Surya (2017) indicate that learners lack problem-solving skills from an early age and core concepts are not fully comprehended by learners that ultimately result in Mathematical challenges at the later stages of their lives. “The importance of having a solid background in Mathematics is well recognized as it serves as a gateway to future professions in a variety of fields worldwide” (Casinillo, 2019, p. 2).

From this analysis it is evident that promoting and mastery of Mathematics in schools is important. It is therefore an expectation that the Mathematical pedagogies in schools be appropriate and correct so that the advantages of Mathematics can be obtained, utilized and applied in the learner's life (Reddy et al., 2015).

The application of technology in the teaching and learning brings into perspective the digital learning pedagogy which is a paradigm for learning which enables learners to be active participants in creating, finding and developing their Mathematical knowledge (Gervasoni et al., 2021). This notion then brings into focus Piaget’s Constructivism ideology which centers on learners who create their own knowledge (Gervasoni et al., 2021).

The teaching and learning models these countries have adopted is experimental, learner centered, hands on and collaborative (Boaler, 2016). Learning and knowledge development is a step-by-step activity which is innovation driven, highly creative, enhances discovery and team effort (Gervasoni et al., 2021). Boaler, (2016) notes that a digital pedagogy is the ultimate paradigm which enables learners and enhances their mindset growth.

The ability to engage in the problem-solving is enhanced through experience using digital pedagogical platforms. Vintere (2018) notes that the best possible way to solve Mathematical problems is through the constructivist approach which is based on the view that knowledge can be acquired when learners create it. As in the case of Japan, knowledge is not created by a teacher. The instructional approach places more emphasis on problem-solving by allowing students a platform to re-invent ideas, shift from a traditional classroom where knowledge source was a teacher to a more learner-centered environment which is enhanced deeper through learner engagement and collaborative work.

There are five aspects similar in the reviewed ICT and non-ICT instructional strategies depicted from these countries, with regards to constructivism as outlined Vintere (2018):

- Their learning strategies enhance or encourage interaction among what learners already know and what ought to be learnt.
- Learning is regarded as a social process and enhances people's relationships.
- Learning occurs within the social and cultural set-ups.
- Learning is regarded as metacognitive. This is an ideology of comprehending the various methods which will lead a learner to a solution.
- Learning has become more learner-centered and learner autonomy is encouraged.

In conclusion, the biggest influence of constructivism in Mathematics was advanced by Piaget, Vygotsky and Glasersfeld who place constructivism as a position of cognitivism and acknowledge that discourse and creation are a "self-organized cognitive process", (Vintere, 2018, p. 6). One can then argue that both ICT instructional support strategies and non-ICT instructional strategies are to some large extent influenced by the theory of constructivism.

One of the countries which takes part in the TIMSS assessment is South Africa and its performance in this assessment is therefore compared to the above countries. The following analysis investigated the South African Mathematical performance of both international standards and the National Curriculum Assessment (NCS).

### 2.5 SOUTH AFRICAN MATHEMATICS PERFORMANCE

As indicated by Reddy et al. (2015), South Africa accomplished a Mathematical score of 372 and a Science score of 358 in TIMSS 2015. South Africa is one of the lower performing of the 39 taking part in this assessment. The distribution of score for Math and Science, from the fifth to 95th percentiles, was 286 focuses and 358 focuses respectively. South Africa has a wide score appropriation, reflecting high instructive disparities which reflect the socio-economic imbalances. From the Figure 2.7 below, South Africa's attainment level is the second lowest after Saudi Arabia (Reddy et al., 2015).

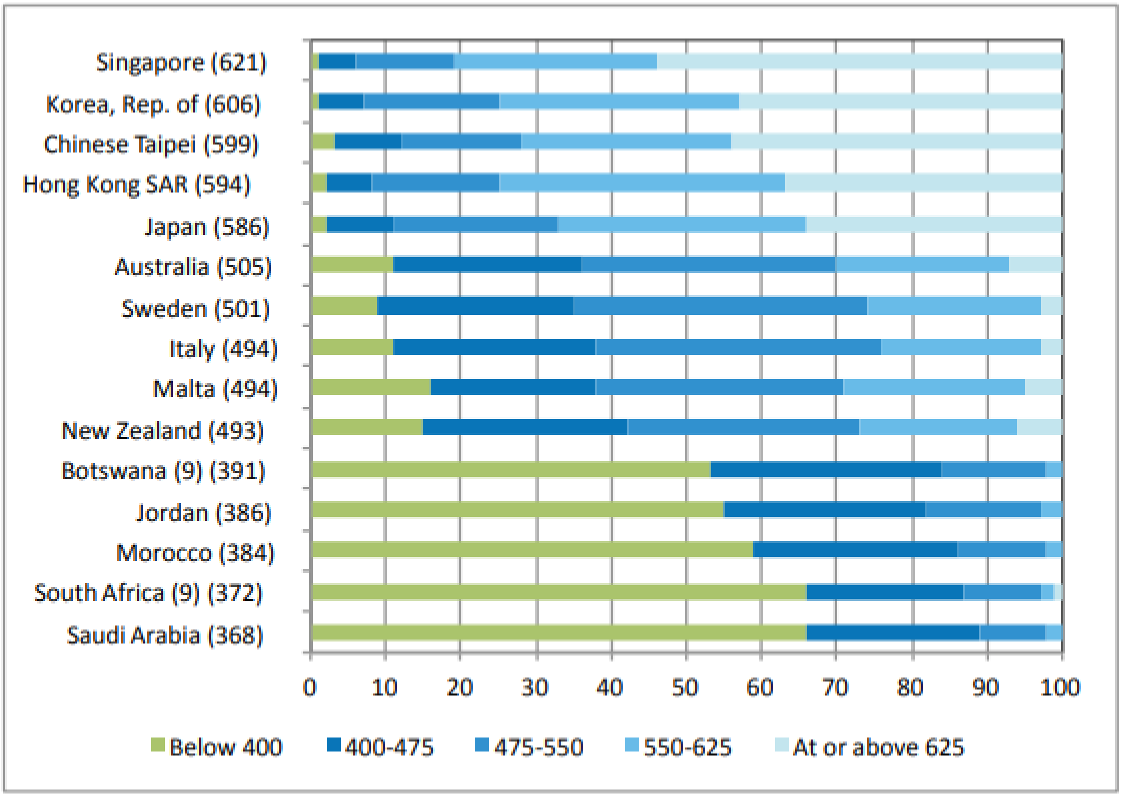



**Figure 2.7 Mathematics profile for selected countries 2015 (Reddy et al., 2015)**

In the TIMSS 2011 reports South African presentation for Math and Science was similar for the 1995, 1999 and 2003 cycles (Reddy et al., 2012). Between TIMSS 2003 and 2011, the Math and Science scores improved by 67 and 64 focuses individually. Somewhere in the range of 2011 and 2015 the Math and Science scores improved by a further 20 and 26 focuses individually (Reddy et al., 2015).

In 2015, 34% of Math students and 32% of Science students accomplished a score of north of 400 places (Reddy et al., 2015). This implies that only 33% of South African Grade 9 students showed accomplishment at a significant level in Mathematics and Science. These students structure the pool who could pick Mathematics and Science as a school subject in the post-Grade 9 stage. The positive news is that 3.2% of Mathematical students and 4.9% of Science students can be ordered at significant degrees of accomplishment for example scoring more than 550 (Reddy et al., 2015). Notwithstanding, it is a fascinating activity to look at the adjustment of the level of South African students who performed over the 400-point TIMSS benchmark for Math and Science somewhere in the range of 2003 and 2015. In 2003, a simple 10.5% of Math students accomplished a score of over 400 focuses. This expanded to 24.5% in 2011 and to 34.3% in 2015. Subsequently, somewhere in the range of 2003 and 2015 there was an expansion of 24 rate focuses on the quantity of students scoring over 400. Science scores followed a comparative example. In 2003, 13.1% of

Science students accomplished a score of more than 400. This rate expanded to 25.2% in 2011 and to 32.3% in 2015 (Reddy et al., 2015).

Although there is a significant improvement over the years (Reddy et al., 2015), South Africa is still regarded as the lowest performing country in the TIMSS assessment since its inception (Sherphard & Van der Berg, 2020). Another review investigates the South African NCS performance especially in Mathematics as outlined below.

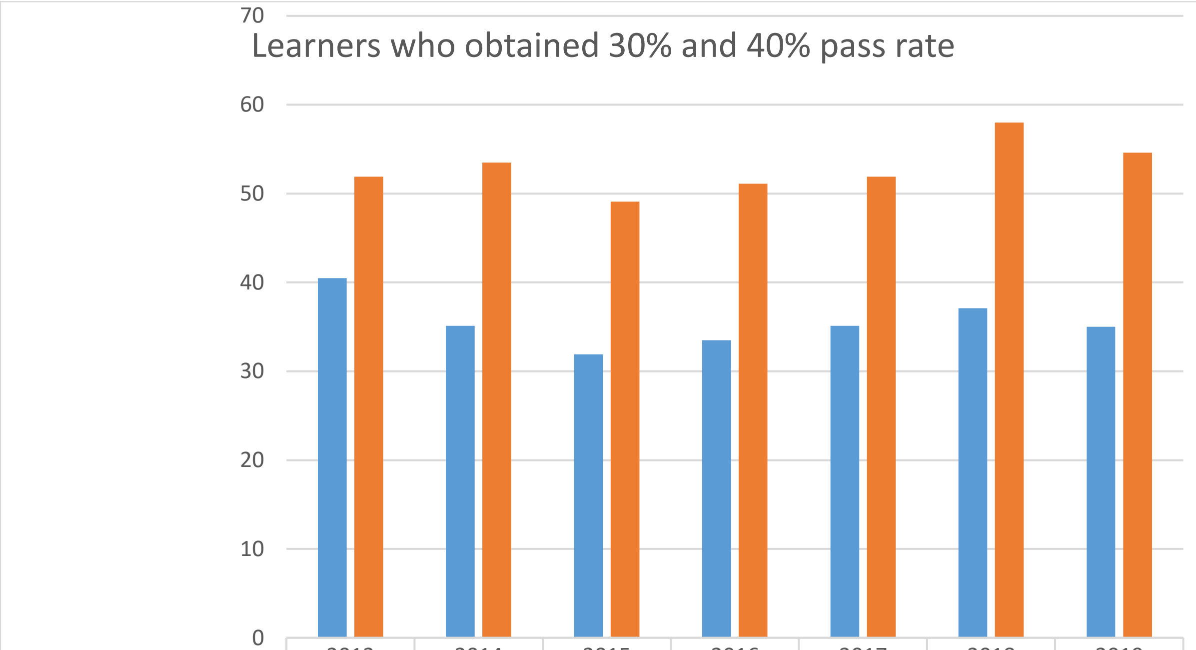
As indicated in the introduction, the South African Schools Act (1996) outlines how learners move from one grade to the next and the introduction of progression policy was also highlighted in DBE (2015). This chapter further gives an outline of the Grade 12 performance dating back from 2013; provincial Mathematical performance, progressed learners' performance especially in Mathematics, and the South African Mathematical performance regionally and internationally. The chapter further examines some of the strategies which were introduced in the GET phase to try to open a space for low ability learners and channel them into a more non-academic stream, offering a more practical area of study offered through TVET colleges**.**

Table 2.1 below is an illustration of Mathematical performance of learners per % score from 2013 to 2016 in the NCS assessment. The table indicates that the majority of learners from 2013 to 2016 who wrote their national senior certificate (NCS) scored below 30%. This was a major concern at the inception of the progression policy because a 30% Mathematical pass does not offer a university entrance into Mathematics or Science subjects. Only 0.8 learners attained between 90 to 100 from 2013 to 2016 (DBE, 2017). At the inception of this policy, many teachers blamed this policy for the high failure rate (Zimasa, 2016).

**Table 2.1 Mathematics performance from 2013 to 2016 NCS Results (DBE, 2017)**

| Year | 0-9.9 | 10-19.9 | 20-29.9 | 30-39.9 | 40-49.9 | 50-59.9 | 60-69.9 | 70-79.9 | 80-89.9 | 90-100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 7.1 | 16.2 | 17.6 | 18.6 | 14.3 | 10.5 | 7.4 | 4.8 | 2.6 | 0.8 |
| 2014 | 9.3 | 18.8 | 18.5 | 18.4 | 12.7 | 8.9 | 6.1 | 4.1 | 2.3 | 0.9 |
| 2015 | 11.2 | 21.3 | 18.4 | 17.1 | 11.6 | 8.3 | 5.4 | 3.7 | 2.1 | 0.8 |
| 2016 | 12.1 | 18.4 | 18.4 | 17.6 | 12.2 | 8.7 | 5.7 | 3.8 | 2.2 | 0.8 |

Figure 2.8 below is a comparison of the number of learners attaining 30% to the number of learners obtaining 40% from 2013 to 2019 in the matric learner performance. The figure denoting the number of learners achieving 30% is much higher than the number of learners performing at 40% from 2013 to 2019 in Mathematics. The trend is the same throughout the seven years and 2015 further saw a significant decline of both percentages. One can therefore draw the conclusion that Mathematical performance in general requires extensive support and intervention for it to improve.




| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|---|---|---|---|---|---|---|---|
| Number obtained 40% | 40,5 | 35,1 | 31,9 | 33,5 | 35,1 | 37,1 | 35 |
| Number obtained 30% | 51,9 | 53,5 | 49,1 | 51,1 | 51,9 | 58 | 54,6 |

**Figure 2.8 Learner achievement below 30 and 40 % in Mathematics (DBE, 2020)**

Table 2.2 and 2.3 below indicate the subject enrolment of Matric learners from 2018 to 2020 in South Africa. There was a general decline in the number of candidates performing at 30% and above in Mathematics nationally over the past three years. The number of candidates who performed at 40% and above in Mathematics remained steady at an average of 35%. Table 2.3 below gives an outline of the number of learners per province attaining above 50%. Only 13.6% of Eastern Cape Grade 12 learners achieved 50%. The comparison between Table 2.2 and Table 2.3 indicate that the majority of Grade 12 learners perform below 50%. This low performance reduces the number of professionals in critical skills (Sherphard & Van der Berg, 2020).

Further examination of Mathematical performance across provinces for the 2020 NCS, as outlined in Table 2.2 below, reveals that Mathematical performance is a challenge across all South African provinces, although some provinces perform slightly better than others. Looking at both the Free State province and Gauteng province, most of their learners perform at 30% in Mathematics, which is over 60% of the learners who completed the Matric examination. The Eastern Cape experienced the lowest Mathematical performance from 2018 to 2020.

**Table 2.2 Candidates' performance in Mathematics by province and level of achievement at 30% and 40% (DBE, 2021)**

| Mathematics | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Province | Total Wrote | | | Total achieved at 30% and above | | | % achieved at 30% and above | | | Total achieved at 40% and above | | | % achieved at 40% and above | | |
| | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 |
| Eastern Cape | 36 449 | 35 270 | 38 717 | 16 576 | 14 747 | 15 364 | 45.5 | 41.8 | 39.7 | 9 438 | 8 354 | 9 119 | 25.9 | 23.7 | 23.6 |
| Free State | 9 722 | 9 886 | 11 040 | 7 226 | 6 769 | 7 321 | 74.3 | 68.5 | 66.3 | 4 794 | 4 445 | 4 712 | 49.3 | 45.0 | 42.7 |
| Gauteng | 35 279 | 35 412 | 37 680 | 26 366 | 24 012 | 24 639 | 74.7 | 67.8 | 65.4 | 18 510 | 16 891 | 17 311 | 52.5 | 47.7 | 45.9 |
| Kwazulu-Natal | 61 686 | 57 882 | 56 506 | 31 191 | 28 065 | 28 924 | 50.6 | 48.5 | 51.2 | 19 327 | 17 306 | 18 869 | 31.3 | 29.9 | 33.4 |
| Limpopo | 39 216 | 34 148 | 38 447 | 21 538 | 18 148 | 19 108 | 54.9 | 53.1 | 49.7 | 13 032 | 11 038 | 12 108 | 33.2 | 32.3 | 31.5 |
| Mpumalanga | 24 207 | 22 621 | 24 663 | 13 112 | 11 672 | 12 560 | 54.2 | 51.6 | 50.9 | 8 029 | 7 289 | 8 228 | 33.2 | 32.2 | 33.4 |
| North West | 9 083 | 8 783 | 9 232 | 6 259 | 5 463 | 5 851 | 68.9 | 62.2 | 63.4 | 3 941 | 3 420 | 3 887 | 43.4 | 38.9 | 42.1 |
| Northern Cape | 2 798 | 2 613 | 2 708 | 1 652 | 1 480 | 1 498 | 59.0 | 56.6 | 55.3 | 1 057 | 898 | 945 | 37.8 | 34.4 | 34.9 |
| Western Cape | 15 418 | 15 419 | 14 322 | 11 718 | 10 823 | 10 261 | 76.0 | 70.2 | 71.6 | 8 746 | 8 110 | 7 785 | 56.7 | 52.6 | 54.4 |
| National | 233 858 | 222 034 | 233 315 | 135 638 | 121 179 | 125 526 | 58 0 | 54 6 | 53 8 | 86 874 | 77 751 | 82 964 | 37 1 | 35 0 | 35 6 |

Table 2.3 below is an analysis of Mathematical performance for Matric learners who obtained 50% per province in 2020. According to the table, no province achieved at least 50% and above for learners who wrote Mathematics for the last three years.

**Table 2.3 Candidates' performance in Mathematics by province and level of achievement at 50% and above (DBE, 2021)**

| Province | Total Wrote | | | Total achieved at 50% and above | | | % achieved at 50% and above | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 |
| North West | 9 083 | 8 783 | **9 232** | 2 231 | 1 870 | **2 373** | 24.6 | 21.3 | **25.7** |
| Northern Cape | 2 798 | 2 613 | **2 708** | 613 | 523 | **574** | 21.9 | 20.0 | **21.2** |
| Western Cape | 15 418 | 15 419 | **14 322** | 6 176 | 5 693 | **5 707** | 40.1 | 36.9 | **39.8** |
| National | **233 858** | **222 034** | **233 315** | **50 701** | **45 090** | **52 073** | **21.7** | **20.3** | **22.3** |

| Province | Total Wrote | | | Total achieved at 50% and above | | | % achieved at 50% and above | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 | 2018 | 2019 | 2020 |
| Eastern Cape | 36 449 | 35 270 | **38 717** | 4 948 | 4 354 | **5 272** | 13.6 | 12.3 | **13.6** |
| Free State | 9 722 | 9 886 | **11 040** | 2 792 | 2 597 | **2 778** | 28.7 | 26.3 | **25.2** |
| Gauteng | 35 279 | 35 412 | **37 680** | 11 635 | 10 542 | **11 510** | 33.0 | 29.8 | **30.5** |
| Kwazulu-Natal | 61 686 | 57 882 | **56 506** | 10 850 | 9 540 | **11 539** | 17.6 | 16.5 | **20.4** |
| Limpopo | 39 216 | 34 148 | **38 447** | 7 006 | 5 886 | **7 233** | 17.9 | 17.2 | **18.8** |
| Mpumalanga | 24 207 | 22 621 | **24 663** | 4 450 | 4 085 | **5 087** | 18.4 | 18.1 | **20.6** |

Looking at Table 2.3 above, there is no province that has produced at least 50% in Mathematics for the past three years. The highest in the last three years is the Western Cape achieving at least 39-40% of their learners passing Mathematics at above 50%. The province with the lowest number of learners attaining above 50% for the last three years is the Eastern Cape with an average of 13%.

The poor Mathematical performance at an FET level is not a surprise, looking at the South African Mathematical performance. From Shepherd and Van der Berg's (2020) extensive data analysis, the performance in regional and international assessments (e.g. South African Consortium for Monitoring Education Quality (SACMEQ3) and TIMSS4) since 1995 onwards, has also indicated low attainment in Mathematics among South African students. South Africa ranked the last amongst 49 participating countries in the TIMSS Grade 4 Mathematical assessment, notwithstanding the fact that Grade 5 students in South Africa were tested with a much simpler assessment.

As outlined earlier in the beginning of this section, sixty-one percent of South African students performed below the low international benchmark of 400 points. The poor performance trend was also visible in the average performance of South African Grade 9 students in the TIMSS 2015 Grade 8 Mathematics assessment, where they ranked second from last, with two-thirds of learners scoring below the international benchmark. 60-80% of public fee-paying and independent school learners performed below the low international benchmark while only 20% of students in public no-fee schools performed the same (Reddy et al., 2016, p. 8).

What is of further concern is the low Mathematical performance of learners that has been seen in several national (e.g., National Science Education Standards (NSES) and Annual National Assessment (ANA), regional (SACMEQ) and international (e.g., TIMSS and Progress in International Reading Literacy Study (PIRLS) assessments of educational achievement that South Africa has participated in since 1995 (Reddy et al., 2015).

There are numerous challenges that South Africa is currently facing; a range of social issues including high levels of unemployment (Spaull, 2013), the challenges due to the Covid 19-pandemic (Daniel, 2020) and variations of livelihood and widespread poverty all of which have a direct impact on learner attainment, especially in Mathematics and Science subjects (Spaull, 2013).

Access to quality of education is regarded as a fundamental human right and each child deserves quality education that will contribute to his or her future (Winnaar et al., 2015). To remedy the low Mathematical performance different provinces came up with intervention strategies aimed at improving learner Mathematical performance. The North West Department of Education established a Mathematics, Science and ICT Unit (MSTU) and the Western Cape Education Department launched the Khanya Project with a mandate to improve Mathematics and Science subject performance in schools. The Minister of Basic Education, Mrs. Angie Motshekga, MP, in 2010, launched the Action Plan to 2014, 'Towards the Realization of Schooling 2025', in order to avoid ad hoc and fragmented interventions. Regardless of the effort in securing access, the quality of education offered differs considerably, especially in Mathematics and Science subjects and Mathematical performance is still very low (DBE, 2017).

Universities are unable to ignore this challenge which is national. The University of Cape Town did an analysis of Mathematics 1 for new students. In this course a disturbing trend of performance was indicated. A 70 % minimum mark for Mathematics in Matric is needed to be admitted into Mathematics 1 at the university. Data from several years show that an average of 33% of students fail this course. The students who are admitted with a 90% mark for Mathematics in Matric regularly obtain a pass in Mathematics 1 with an average mean of 64% and the ones who obtained between 80% and 89% in their NCS attain at least an average mean of 47% which is a failure. Those who obtain from 70% to 79% in Matric attain at least an average mean of 43% (Maluleke, 2019).

Unless a student achieved a distinction for Mathematics at school level, they are at risk of failing it at university level. It is assumed that learners who do not attain in Mathematics 1 will ultimately spend much time risking being excluded from the university (Maluleke, 2019).

Several interventions have been put in place at the schools recently in offering extra help to students. These comprise Mathematics Labs, workshops on Saturdays and even offering resources which are multilingual to support students who are not yet fluent in the medium of instruction (Shepherd & Van der Berg, 2020). The failure rate nevertheless remains at one third of the class.

This review raised several important outcomes. According to Maluleke, (2019) the following questions were raised from the findings:

• What would be the most appropriate curriculum to ensure a smooth transition from school mathematics to university mathematics?

• Do various disciplinary disciplines, such as actuarial science, chemistry and engineering, require distinct types of Mathematical courses?

• How can the curriculum's pacing accommodate varied learning styles?

• How may educational ICT assist in the development of new methods of teaching and learning mathematics?

However, as indicated by Spaull (2013) there are global issues, not unique to the South African education system. Another contributing factor to the low Mathematical achievement is poor Mathematical knowledge of teachers of Mathematics in South Africa. It is widely known that South Africa ranks near the bottom of the globe in competitiveness s urveys conducted by the World Economic Forum, as well as the TIMSS rankings (Reddy et al., 2015). In their programme to improve Mathematical performance for a primary township school, Butterworth (2018) indicated that digital support tools are essential practical tools that make teaching and learning more learner-focused resulting in improved performance.

As indicated by Sinyosi (2015), most schools in South Africa are low performing; there is a high number of learners in a single class with an average of 45 to 50 with limited resources, especially technological and scientific teaching aids. There is also a poor performance in national and international Mathematics assessments (Reddy et al., 2015).

Despite numerous interventions implemented, South African students continue to obtain low marks in Mathematics (Mampane, 2017). One of the primary explanations for this poor performance according to Mathematical studies is the lack of core foundation phase understanding (Feza & Diko, 2015). UMalusi, the education quality assurer, indicated in 2017 that South Africa's Mathematics and Science marks are improving, but the true reflection is the opposite. However, both subjects had a lesser number of learners writing the exams in 2016, resulting in the lowest number of actual passes since 2014 for Mathematics, and 2015 for Science (Businesstech, 2017) and this remained a concern for 2019 Grade 12.

A study conducted by Sinyosi (2015) indicates a gap in Mathematical comprehension at foundation phase level. Learners were not adequately prepared in the lower grades to be able to solve high-level Mathematical challenges in the senior grade. In other words, learners lacked a proper foundation and background in Mathematics. There is a gap in comprehension and application of common Mathematical basics from previous grades. Due to certain social disparities, such as the expertise or the resources to assist, homework assistance was also very limited. Learners showed negative attitudes towards their teachers and the subject. Learners were not self-motivated in Mathematics. In her article, Mampane (2017) asserts that, citing White paper 6 of 2001, all learners irrespective of their educational barriers, require extensive support in attending the promotion requirements to the next grade.

A number of variables in TIMSS 2002 and 2011 have been cited as factors which directly impact learner attainment. These are factors such as English-language ability and Mathematics performance (Dempster & Reddy, 2007); the approach towards Mathematics, Science and their attainment (Juan et al., 2018); the relationship between Mathematical performance and reaching Grade 12 (Reddy et al., 2015); home and school resources as predictors of Mathematical performance (Visser et al., 2015); comprehending some of the factors in schools which may pose a direct influence towards student achievement levels (Winnaar et al., 2015); and the interrelationship between language and achievement (Prinsloo & Rogers, 2013).

Van der Berg et al. (2019) have outlined that there is high performance apparent in students attending schools where teacher knowledge and pedagogical competency is high in Mathematics, and these schools are mostly found in advantaged communities with fee paying schools. "Although a sound knowledge of Mathematics is generally regarded as a prerequisite for effective Mathematics teaching, there is scant evidence linking teacher preparation in Mathematics directly to the achievement of students" (Mullis et al., 2012, p. 177).

While teachers' experience and qualifications are considered by policymakers and researchers as a basis to assess educator quality, these traits do not offer enough explanation in terms of educator performance in a classroom to improve learner attainment (Du Plessis & Mestry, 2019). This research aims to illustrate that in addition to what has been echoed by previous scholars, there are more specialized pedagogic theories which would assist progressed learners to achieve. These have not yet been researched; support strategies for progressed learners, how they are applied and the benefit or results thereof.

## 2.6 PROGRESSION POLICY

Despite the conflicting theories pertaining to progression policy (Zimasa, 2016), the South African Department of Basic Education (DBE) took a resolution to introduce progression policy from FET phase and in 2012, an instruction was communicated that learners in FET must be progressed to the next grade (DBE, 2015). This saw the first cohort of progressed learners sitting for their final Matric examination in 2013 (DBE, 2020).

Defenders of progression policy contemplate that repetition has social and scholastic expenses and scarcely any drawn out advantages. Holmes and Matthews (1984, p 17) argue that "the individuals who keep on holding students at grade level do so despite aggregate examination proof demonstrating the potential for negative impacts reliably exceeding positive results". These negative impacts incorporate an improved probability of exiting of school before completion (Jimerson, 2001) and conduct issues, including delinquency (Chandler et al., 2017).

The monetary expenses of repetition are additionally high (Walton, (2018). These incorporate not just the expense of having extra students in the class, but in addition, the lower acquiring potential such students will have once they exit, instead of graduating from school. Brophy (2006) states that repetition and ability grouping "[help] advantaged groups, [create] further barriers for the disadvantaged, and [promote] segregation and stratification" This is potentially deteriorated by the fairly self-assertive nature of advancement, movement and reiteration choices, especially in developing countries (Brophy, 2006).

Defenders of progression policy concede that students may show an underlying improvement in examination comparative with coordinated controls in the present moment, they however, call attention to the fact that this advantage vanishes in the long haul (Van der Berg et al., 2019). Opposers of progression may contend that advancement on legitimacy, as characterized by school educational plans, serves every learner's inclination by diverting students into academic choices generally appropriate for their capacity.

Walton (2018) disproves this contention by expressing that capacity isn't static and school appraisal not faultless, thus potential to succeed cannot really be dictated by performance in school examinations and assessment at a specific time. Teachers are the main opponents of progression policy. Their interests are at times put down by specialists as being just educated by reasonable information on the present moment advantages of repetition, instead of by thorough research of both short-and long-term impacts of repetition (Ferrão et al., 2017).

Regardless of an ongoing discussion pertaining to the progression policy, it is in its implementation stage and teachers must come up with strategies to support these learners.

Defenders of the special advancement referred to as progression, contemplate that repetition has social and scholastic disadvantages, and scarcely any drawn out advantages. Hare (2020, p. 17) argues, “the individuals who keep on holding students at grade level do so despite aggregate examination proof demonstrating the potential for negative impacts reliably exceeding positive results". These negative impacts incorporate an improved probability of exiting of school before completion (Jimerson, 2001) and conduct issues, counting delinquency (Chandler et al., 2017) also the monetary expenses of repetition are additionally high (Walton, 2018).

These incorporate not just the expenses of having extra students in the class. In addition, the lower potential such students will have once they exit, instead of graduating from school. Brophy (2006) states that repetition and ability grouping “[help] advantaged groups, [create] further barriers for the disadvantaged, and [promote] segregation and stratification.” This is potentially deteriorated by the self-assertive nature of advancement, movement and reiteration choices, especially in developing countries (Brophy, 2006).

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The following Table 2.4 below indicates the performance of progressed learners after the extensive support they received. These are the results of 2020 Matric progressed learners in each province. Nationally of the 65,499 progressed learners who sat for their Grade 12 examination, 24,244 achieved making it a 37.0 % pass.

Table 2.4 below indicates the number of progressed learners who sat for NCS examination in 2020. The presentation is made per province. It also indicates the number of learners who were progressed and who sat for their examination. For instance, in the Eastern Cape, the number of learners who registered were 9759 but 9025 sat and 734 did not sit for their Matric exams and only 2260 achieved. This implies that not all progressed learners are able to sit for their exams and not all pass their Matric examination.

**Table 2.4 Number who wrote and achieved NSC as progressed learners in 2020**

| Provinces | Progressed Candidates | | | |
|---|---|---|---|---|
| | Entered | Wrote | Achieved | % Achieved |
| Eastern Cape | 9 759 | 9 025 | 2 260 | 25.0 |
| Free State | 5 258 | 4 890 | 2 682 | 54.8 |
| Gauteng | 11 655 | 10 698 | 4 382 | 41.0 |
| KwaZulu-Natal | 15 447 | 13 851 | 5 501 | 39.7 |
| Limpopo | 12 050 | 11 783 | 4 195 | 35.6 |
| Mpumalanga | 6 564 | 6 262 | 2 677 | 42.7 |
| North West | 4 189 | 3 995 | 1 306 | 32.7 |
| Northern Cape | 2 427 | 2 265 | 554 | 24.5 |
| Western Cape | 3 216 | 2 730 | 687 | 25.2 |
| National | **70 565** | **65 499** | **24 244** | **37.0** |

"24 244 of the progressed learners that wrote all seven subjects obtained the NSC. This number increased from 23 483 in the November 2019 NSC. This translates into a percentage increase of 3.1%" (DBE, 2021). The table further indicates that only 37% nationally attained their NCS certificate.

In its earlier inception, this policy received negative views from other stakeholders within the education sector and some have criticized it (Zimasa, 2016). Several educators had voiced a worry that the policy may hinder these learners other than aiding them and increase the failure rate in higher grades and this is seen in Matric results (Spaull, 2013), but Table 2.4 indicating 2020 results and Table 2.5, indicate a positive impact of progression policy towards progressed learners who sat for their matric in both 2019 and 2020. This is in line with Nomahlubi's (2018) argument that if adopted and implemented correctly at higher grades as seen in the 2018-Matric results, it can produce positive results.

In 2013, during the inception of this policy 799306 Matric candidates sat for their examination, 65671 were progressed learners, constituting 9.8% (Reddy et al., 2015). In their diagnostic results analysis for this class, DBE (2016), 22060 progressed learners (37.6%) passed with 3297 obtaining bachelor passes, 8473 attained diplomas and 10264 obtained higher certificate passes, with 1081 progressed learners obtaining distinctions.

Table 2.5 below indicates the 2019 progressed learners' achievement type. Although there are conflicting ideas and views regarding this policy, there are learners who have benefited from the progression policy who may not have written their Matric examination in 2019 should they have been retained. 68% nationally of progressed learners have passed their matric examination. These are learners who were meant to have been retained in either Grade 10 or Grade 11.

**Table 2.5 Achievement of progressed learners 2019 NCS results (DBE, 2020)**

ACHIEVEMENT TYPES OF PROGRESSED LEARNERS 55

| Province Name | Total Wrote | Achieved Bachelor | % Achieved Bachelor | Achieved Diploma | % Achieved Diploma | Achieved H-Cert | % Achieved H-Cert | Achieved NSC | % Achieved NSC | Total Achieved | % Achieved |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EASTERN CAPE | 4 152 | 384 | 9.2 | 1211 | 29.2 | 1109 | 26.7 | 8 | 0.2 | 2 712 | 65.3 |
| FREE STATE | 3 230 | 285 | 8.8 | 1051 | 32.5 | 913 | 28.3 | 0 | 0.0 | 2 249 | 69.6 |
| GAUTENG | 6 573 | 870 | 13.2 | 2 153 | 32.8 | 1 515 | 23.0 | 1 | 0.0 | 4 539 | 69.1 |
| KWAZULU-NATAL | 6 462 | 965 | 14.9 | 2 140 | 33.1 | 1 531 | 23.7 | 4 | 0.1 | 4 640 | 71.8 |
| LIMPOPO | 4 473 | 446 | 10.0 | 1 287 | 28.8 | 1 256 | 28.1 | 0 | 0.0 | 2 989 | 66.8 |
| MPUMALANGA | 4 445 | 569 | 12.8 | 1 482 | 33.3 | 1 165 | 26.2 | 0 | 0.0 | 3 216 | 72.4 |
| NORTH WEST | 2 685 | 276 | 10.3 | 932 | 34.7 | 873 | 32.5 | 0 | 0.0 | 2 081 | 77.5 |
| NORTHERN CAPE | 568 | 36 | 6.3 | 167 | 29.4 | 138 | 24.3 | 0 | 0.0 | 341 | 60.0 |
| WESTERN CAPE | 1 910 | 81 | 4.2 | 281 | 14.7 | 354 | 18.5 | 0 | 0.0 | 716 | 37.5 |
| NATIONAL | 34 498 | 3 912 | 11.3 | 10 704 | 31.0 | 8 854 | 25.7 | 13 | 0.0 | 23 483 | 68.1 |

Table 2.5 above and Figure 2.7 below indicate the number of learners who were progressed from Grade 11 in 2018 and sat for the matric examination in 2019. The provincial breakdown indicates that only Western Cape progressed learners achieved below 50%, the highest

being North West province with 77.5% learners who were progressed passing their matric examination.

Table 2.5 further indicates the performance of progressed learners in terms of pass classification that is how many learners obtained bachelor passes, diplomas and certificates. Nationally, 11.3% learners obtained a bachelor's degree pass, with Kwazulu Natal achieving the highest bachelor passes while 31.0% obtained a diploma nationally and 25.7% obtained a certificate pass. The above analysis thereby indicates a positive impact of progression policy in South Africa.

It has been established above, that progressed learners have the potential to achieve in their matric examination but what is yet to be established is their subject performance especially in Mathematical subjects.

The Figure 2.9 below is an analysis of the provincial number of progressed learners in 2019 who sat for their NCS. Northwest had the highest number of learners who were progressed and sat for their matric exams while Western Cape Province had the least number of progressed learners.

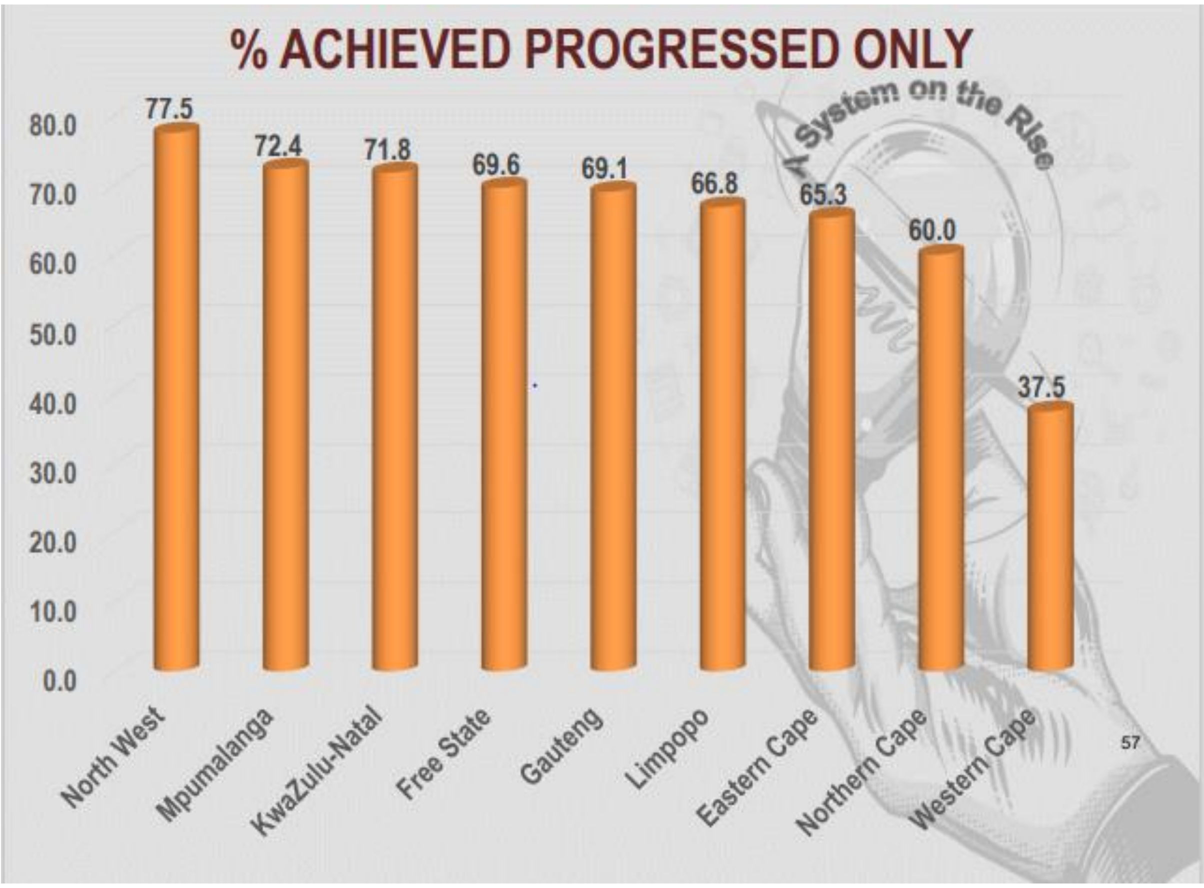



**Figure 2.9 Progressed learners' achievement per province (DBE, 2019)**

The following Table 2.6 examines each subject enrolment and performance of learners in the 2019 Matric results according to DBE (2020). It is an analysis of the distinctions obtained by progressed learners in all the subjects in the Matric class of 2019. A distinction is a pass percentage above 80% (DBE, 2020).

**Table 2.6 Progressed candidates' distinctions (DBE, 2020)**

76

PROGRESSED CANDIDATES DISTINCTIONS

| Subject | Total Wrote | Distinctions | % Distinctions |
|---|---|---|---|
| Accounting | 7 538 | 7 | 0.1 |
| Afrikaans First Additional Language | 4 129 | 7 | 0.2 |
| Afrikaans Second Additional Language | 3 504 | 1 | 0.0 |
| Agricultural Sciences | 15 798 | 2 | 0.0 |
| Business Studies | 22 629 | 16 | 0.1 |
| Computer Applications Technology | 2 205 | 0 | 0.0 |
| Dramatic Arts | 1 657 | 1 | 0.1 |
| Economics | 14 461 | 3 | 0.0 |
| Engineering Graphics and Design | 3 219 | 3 | 0.1 |
| English First Additional Language | 108 831 | 24 | 0.0 |
| French Second Additional Language | 17 | 9 | 52.9 |
| Geography | 39 200 | 11 | 0.0 |
| History | 30 736 | 113 | 0.4 |
| Information Technology | 85 | 1 | 1.2 |
| IsiNdebele Home Language | 1 528 | 30 | 2.0 |
| IsiXhosa Home Language | 16 766 | 122 | 0.7 |
| IsiZulu Home Language | 36 364 | 117 | 0.3 |
| Life Orientation | 123 104 | 1249 | 1.0 |
| Life Sciences | 32 379 | 28 | 0.1 |
| Mathematical Literacy | 39 740 | 47 | 0.1 |
| Mathematics | 13 671 | 12 | 0.1 |
| Physical Sciences | 11 354 | 25 | 0.2 |
| Sepedi Home Language | 14 069 | 0 | 0.0 |
| Sesotho Home Language | 8 433 | 18 | 0.2 |
| Setswana Home Language | 12 203 | 11 | 0.1 |
| SiSwati Home Language | 5 555 | 4 | 0.1 |
| Tourism | 24 523 | 40 | 0.2 |
| Tshivenda Home Language | 6 307 | 228 | 3.6 |
| Visual Arts | 384 | 5 | 1.3 |
| Xitsonga Home Language | 5 619 | 0 | 0.0 |

Looking at Mathematics and Mathematical Literacy from Table 2.6, only 12 learners of the 13,671 progressed learners who wrote Mathematics achieved above 80%, which is a distinction. The majority of learners obtained distinctions in Life Orientation and a significant number in languages.

From the above tables and figures, one can conclude that as much as there is a significant positive result of progressed learners, their impact on the pass rate is still in serious debate. What remains evident, is regardless of the criticisms, challenges and benefits brought about by this policy, it is in existence, and learners are being progressed yearly. A proper support strategy both digital and non-technological needs to be implemented to ensure that the benefits surpass the challenges or disadvantages, especially in Mathematics where most learners are condoned.

## 2.7 THEORETICAL FRAMEWORK: CONNECTIVISM THEORY

### 2.7.1 INTRODUCTION

This theoretical framework gives an investigation into the theory selected for this research. Ishtiaq (2019) clarifies the fact that theories which are relevant to a particular study and the methodology incorporated are a basis upon which research is based. The theoretical framework is established to show how a study progresses, builds information, to conceptualize the investigation, to re-assess research design and act as a basis for result interpretation (Laderman & Lederman, 2015). The learning theory expects to help the researcher in improving comprehension of how individuals learn (Khan et al., 2018). The theory that is utilized and examined is the connectivist theory, as outlined below.

This is a recent theory proposed by Siemens (2005) and Downes (2012). This study has applied connectivism theory because it strives to comprehend learning as a process of linking specialized nodes, networks and sources of information. Siemens (2005) asserts that learning in this theory is at times through non-human appliances. Connectivism theory is a learning theory introduced with the view that knowledge can be derived from any source not solely from a single individual (Mechlova & Malcik, 2012). They further assert that “knowledge is found in systems which could be obtained through people’s participation in various activities some of which are digital”.

The principle focal point of the connectivist theory is to comprehend the compelling method of learning through cooperation and collaboration between nodes in a digital world. With the quick increment of web utilization in both rich and poor countries, knowledge sharing has become more viable. Kop and Hill (2008) notice that the significance of the hypothesis depends on its "socio-innovative nature" in which teachers and learners structure organizations of learning networks and stages.

The study plans to investigate the strategies that can be applied to support and influence the incorporation of ICTs as a device to enhance teaching and learning to support progressed learners. The connectivist theory supports this study as it investigates ways in which educators can coordinate and use ICTs as an approach to guarantee that students become dynamic members in the data society and to change the manner in which teaching and learning happens in or outside the classroom, especially for low ability learners.

The study explored connectivism as a theory of the digital age that denotes that learning does not only rely on the formal classroom learning, but that knowledge formation and distribution can be done through learners and digital devices. This theory uses nodes, links and networks as a form of data sources and distribution. The study further briefly explored the different theories in comparison with connectivism and which gap it fills in the digital age. The section also examined how connectivism can be applied within ICTs, as its role is to facilitate interactions using digital links and nodes, and how it can be applicable in the teaching and learning of Mathematics.

### 2.7.2 CONNECTIVISM THEORY

According to Tafor et al. (2016) connectivism is described as a digital age theory emanating from the evolution of ICTs. Using the internet, learners and educators are now involved in a collaborative learning environment and these comprise of online classrooms, social networks and virtual reality programs which form, distribute and share knowledge. Mattar (2018, p. 77) asserts that "learning is no longer a process that is entirely under the control of an educator but can occur even outside the conforms of communities".

This is a theory that was proposed by George Siemens, and it has been described as a theory which exists in the digital era (Bell, 2010). Connectivism theory was applied in the study in order to comprehend the integration of ICTs in the 21$^{st}$ century needs of the learner and ensures that the application of technology within education achieves its objectives.

As explained by Kop and Hill (2008) this sharing of information process occurs through social media network tools and can be attained in various digital ways. Kop and Hill (2008) further stress that the critical core objectives of connectivism is to contribute towards learning through searching of recent information and being able to share the information required through various networks.

This however, as echoed by Siemens (2006) should be done by learners and teachers who have the ability to use available digital platforms and tools accessible for information sharing. Furthermore, (as advised by Downes (2008)) networks play a pivotal role in the connectivist environment.

Siemens (2004) has highlighted certain principles, which guide connectivism ideology, and these shall be elaborated on in Chapter 3 of this study. However, these principles highlight that learning acts as a distribution of knowledge through and within networks (Bassette, 2014).

It therefore occurs even outside the individual (Siemens, 2006), among other individuals and organization databases, and these outside connections and links facilitate our ability and access to learn (Downes, 2019). This theory utilizes nodes to link networks while facilitating learning. It occurs as people share interests, information and opinions in online learning spaces (Mattar, 2018). Tafor et al. (2016) further emphasize that in the connectivism learning space learners are at the core of the process of learning taking an active role in getting access to online information.

Abhari (2017) emphasizes that connectivism explains the ability to learn which is more vital as knowledge is shared across networks making learners navigate links in the process of knowledge acquisition. Connectivism strives to make an interpretation and comprehension of the teaching and learning process in the digital world (Cabrero & Roman, 2018). Its ability to connect information sources and the learner's ability to see or create connections are the core learning skills (Abhari, 2017). Connectivism theory shows the ability for inclusive education because it emphasizes issues around diversity, openness and flexibility (Abhari, 2017).

Connectivism enhances social interaction enabled by ICTs; it enhances collaborative learning (Cobrero & Roman, 2018). Learners become the centre of the learning process (Tafor et al., 2016) and it assesses contradictions among ideas, fields and concepts (Abhari, 2017). The learners become active and creative as they are required to adapt to the constantly changing world through the creation of new networks, connections and search for patterns (Cabrero & Roman, 2018).

In the process of learning, knowledge evolves quickly; there is continuous growth as more networks are formed and ideas are shared (Cabrero & Roman, 2018), the flow of knowledge depends on the world perspective (Downes, 2019). Mohamed et al. (2017) citing Downes (2010) in their analysis view connectivism as a theory that enhances diversity, autonomy, interaction and openness. They assume that being a part of a network, talking, searching for information and ideas provided by others leads to a creation of knowledge. Connectivism enhances active engagement between individuals and resources in the knowledge creation process, other than knowledge transfer from the educator to the learners (Mohamed et al., 2017).

Connectivism has changed the learning perspective to facilitate learning in technological environments, other than older theories that overlooked this perspective (AlDahdouh, 2019). Connectivism draws connections between phenomena either human or digital learning; it occurs outside of people (Siemens, 2006) and focuses on linking specific information sets and networks which allows us to learn more with up-to-date information.

Kropf (2013) alludes to Siemens (2006) explaining that contemporary learning takes place through the interlink of networks when people exchange ideas, information, viewpoints, special skills and thoughts through digital environments (Kathleen, 2011). Technologies from the internet consist of records and search modes which are proficient in storing data from online new e-books, journals, YouTube videos and podcasts (Marhan, 2006). Jung (2019) asserts that connectivism is a learning theory which consists of a diverse sequence of nodes to connect hundreds of networks to enable synchronous and asynchronous learning (Kathleen, 2011).

This information gives people an opportunity to obtain real and consistent data from numerous sources to re-create and distribute to their community links, and they further have an opportunity to scrutinize and remove material that is irrelevant. In the digital era, connectivism emerges as a process of creating networks where knowledge and teaching methods are delivered through networking of individuals and ICTs, and learning is through the process of exploring various links (Siemens, 2006).

As explained by Bassette (2004) this learning theory, if used and appropriately applied, could change the current education system for the better. It shifts from a teacher centred approach to a more learner centred approach. It discourages educators from controlling the process but rather facilitating the teaching and learning process. When content is derived through various networks and research and dialogue is encouraged, learning becomes continuous and fruitful (Siemens, 2006).

Siemens (2006) outlines that knowledge needs an assortment of ideologies to present an idea, and to give rise to the selection of best methodologies and teaching practices. Learning is a knowledge creation process, which is through specific nodes or information sources. Vas et al. (2018) outline that knowledge rests in networks. Content or learning strategies may be vested in non-human appliances, and learning is aided by ICTs (Marhan, 2006). Every learner can continue learning given a proper learning environment; it is a continuous process. Once a learner is given space to create his / her own learning, he or she can recognize connections, see new ideas and formulate concepts beyond the classroom which could be refined in formal learning (Bell, 2010).

In connectivism according to Siemens (2005) "learning is a process that occurs within nebulous environments of shifting core elements not entirely under the control of the individual. Learning can reside outside of ourselves but within an organization or data and is focused on connecting specialized information sets, and the connection that enables us to learn more are more important than our current state of knowing" (Siemens, 2005, p. 4).

In connectivism, Altuna and Lareki (2015) point out that the role of an educator is different compared to behaviourism and constructivism whereby an educator in the teaching and learning, acts as a mediator of information sources to enable learners to fully and actively participate in a task. As outlined by Nomahlubi (2018) and Wicks and Raborife (2017) progressed learners require extra and constant support unlike high ability learners who can navigate with minimal guidance in knowledge construction. Progressed or low ability learners as further indicated in DBE (2017) require a supportive community of learning in the form of study groups and other digital sources of data to learn effectively.

Figure 2.10 below shows how connections and networks function in the connectivism set up. Both a teacher and a learner become part of a network, and information does not only reside in a single classroom or one information source, but from multiple sources, which include nonhuman appliances such as webpages (Downes, 2019).

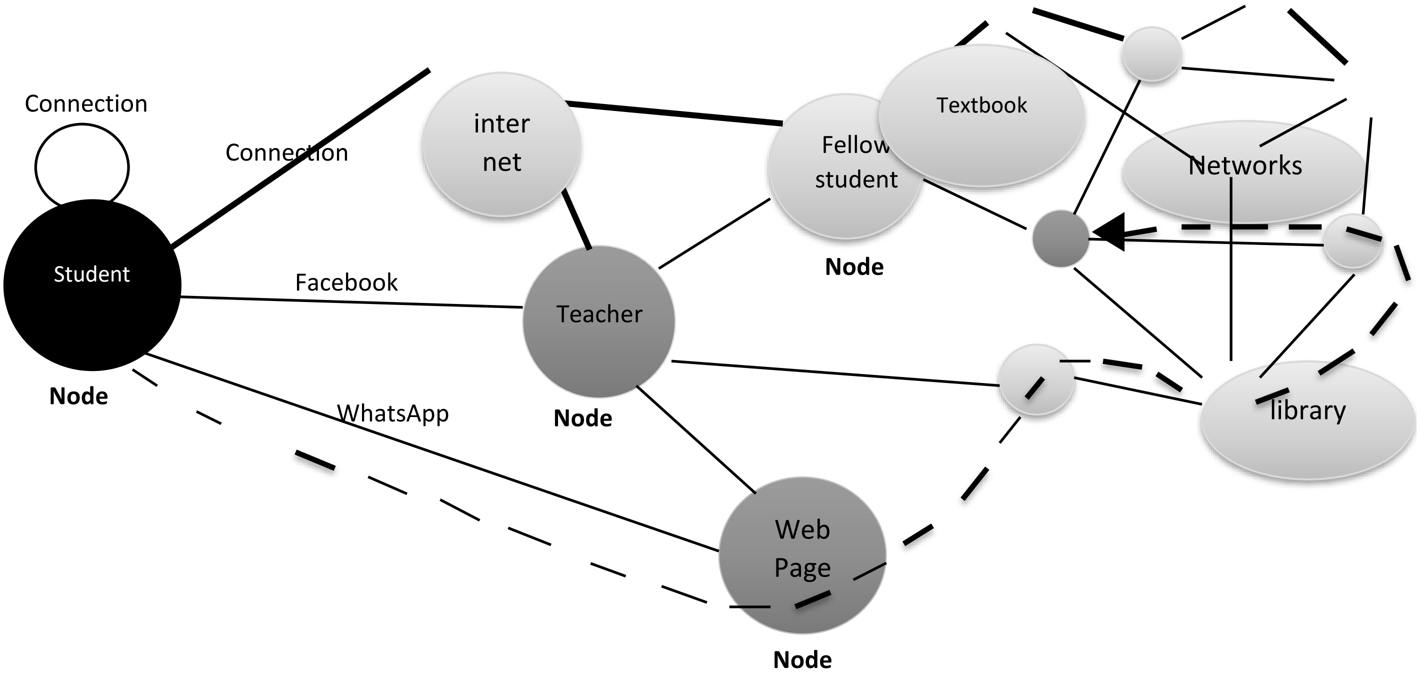



**Figure 2.10 Connectivism Model (Downes, 2019)**

The above Figure 2.10 is an illustration of the connectivism theory in the teaching and learning process. This theory is identified as a theory of the digital age (Siemens, 2006). It thereby draws an assumption that knowledge is transferred and stays outside of humans (Jirasatjanukul & Jeerunsuwan, 2018). Downes (2008) further asserts that knowledge is transferred through a network of connections making learning to be a learner's ability to create and transverse these networks. Shrivastava (2018) says previous theories are to lose their significance in the digital era if the use of ICTs are not embedded in them. Downes (2019) further notes that knowledge is created both by humans and digitally, thereby causing rapid changes. It is therefore the teacher's responsibility to create networks that will enhance knowledge formation and acquisitions and stay abreast with the fast changes.

Features of connectivism as described by Siemens (2005) and Downes (2008) cited in Boitshwarelo (2011):

- The main idea in this theory is that learners connect to a community of learning; they acquire knowledge while they also contribute to knowledge. This can be derived through various dialogues, and therefore this means learning is mostly learner centred.
- This learning group is regarded as a node that forms part of a learner network. These networks are self-created, managed and controlled. The tempo of learning is also managed by a learner through the educator's guidance, and so instead of rushing to complete the syllabus, a progressed learner may decide on the learning pace which may ultimately yield positive results.
- Knowledge does not reside in a single individual but is shared among networks and it grows as it is transported from one source to the next. This therefore allows various views or methods to be used to solve different problems especially in Mathematics subjects.

George Siemens (2006) who is the originator of the connectivist theory depicts the connectivist learning hypothesis as a structure which describes learning as an organization affected by innovation and social networks. Connectivism is the beginning stage for information to be actualized by learners (Goldie, 2016). As indicated by the connectivist model, the learning communities are alluded to as a network that occurs out of the links and nodes found in organizations, libraries, sites, websites, data sets or some other wellsprings of data.

Siemens (2006) characterizes these networks as associations between elements which can be people, gatherings, frameworks, fields, thoughts or network ideas (Bell, 2010). The execution of ICTs can be utilized for long range interpersonal communication, as well as for learning purposes which may incorporate knowledge formation or sharing of data with others, inside our informal organizations or people from anyplace on the planet. The organization with which students can interface, might be as small as a neighbourhood or worldwide (Goldie, 2016).

There are other learning theories that existed prior to connectivism within the literature. These have affected the introduction of the connectivist theory and ought to be viewed as a base for each other (Van Der Berg et al., 2019). The learning theories are behaviourist, cognitivist and constructivist and were created in the age when ICT was not exceptionally functional in teaching and learning. One cannot refer to the connectivist theory without the reference to behaviourism, cognitivism and the constructivism.

Table 2.7 below illustrates the progression of the theories and the features that differentiate them. Connectivism is a theory that came after the inception of the theories illustrated below and its objective is to fill the gap brought by the introduction of technology into the teaching and learning era (Siemens, 2006). The discussion indicates the influence these theories have on connectivism theory.

**Table 2.7 Comparison of theories according to Weegar and Pacis (2012)**

COMPARING LEARNING THEORIES

| THEORIES | LEARNING CONTEXT & PROCESS | LEARNER'S ROLE AND PLACE | | HOW LEARNING OCCURS/OUTPUT |
|---|---|---|---|---|
| **BEHAVIORISM** **Teacher-centered** **Teaching centered on what & how** | Stimulus \|\|Classical conditioning \|\| Operant conditioning | Reaction [positive or negative] | Positive reinforcement Negative reinforcement; Experience is viewed as educative | Learning is sequential, learners are viewed as robots Content-oriented |
| **CONSTRUCTIVISM** **Learner-centered** **Learning centered on why, what & how** | Sociocultural environment (family, community, society) | Learner's agency is emphasized; task-based | Prior knowledge is important; similar to connectivism and andragogy; output implies adjustment; Experience is viewed as educative | Learning doesn't have to be sequential or lineal; task-based learning (Eg.: communicative language teaching or task-based language learning) |
| **COGNITIVISM** **Learning centered on why, what & how** | Emphasis on thought process -mental process Critical role of the environment; perception, behaviors or actions are rooted in experience and a thought process | Learner's agency is important (like behaviorism); Prior knowledge also important; task-based | Amount of information can influence ability to retain information (cognitive load); information representation & retrieval (Computational linguistics); experience is viewed as educative | Zone of proximal development is important in skill development; problem solving |
| **CONNECTIVISM** **Learner-centered** **Learning centered on what & how** | Learning occurs in a network/group; significance learning through new technologies (Facebook, online learning communities) | Learner's network influences his/her ability to access to information through social network (similar to social capital); task-based | Learning is dynamic and changes according to network; network expansion dependents on learner's dynamism; learner's experience is viewed as educative | As network expands, individual can increase knowledge; rich network implies richer knowledge and poor network poorer access to information |

### 2.7.3 THEORIES PRIOR TO CONNECTIVISM

The following section aims to give an outline of theories developed before connectivism and how they have contributed to the development of connectivism.

### a) The behaviourist learning theory

Reimann (2018) asserts that behaviourist learning is a psychology-grounded educational line of thought, in view of the possibility that conduct can be explored logically without thought of psychological states. The essential thought is that learning is affected exclusively by actual factors like ecological or material support. By excusing the impact of mental factors, behaviourists recommend that unrestrained choice is a deception and that reactions can be resolved and moulded.

This theory was established by Ivan Pavlov in the 19th century and its main point of focus was what can be observed, that is the way people behave, and to create change (Reimann, 2018). According to behaviourists, learning occurs when assessments are repeated until a learner obtains a set outcome. Knowledge is regarded as a physical object that a learner must comprehend, and learning is a process in which knowledge is transferred to the learner through rewards and punishment (AlDahdouh et al., 2019).

Behaviourists advocate a method of drill and practise type of learning. They additionally stress the ideology that the learning comes from observing events at their natural occurrence (Feldman & McPhee, 2008). A learner, from the behaviourist viewpoint, accomplishes learning by having the option to repeat or imitate what has been educated without tapping into the learner's thoughts or perspectives.

In a behaviourist school of thought as explained by AlDahdouh, et al. (2019) a behaviourist teacher plays to a greater degree, a prevailing and influential position towards instructing and sharing of information, which is through nodes. For example, administering, imparting knowledge, passing on information and planning. The educator additionally has the duty of establishing a climate that will assist students with learning. The behaviourist accepts that the climate wherein learners are set assumes an imperative part in their degree of learning. The behaviourists utilize advanced technologies comprising of cautiously planned learning content units, known as frames (Staddon, 2017) and these include drills, tutorials, simulations and games.

Even with the advancement of different theories, there are some teachers who have discovered the usefulness of this theory in accelerating the way towards moving information (AlDahdouh et al., 2019).

On the other hand, Reimann (2018) has investigated the utilization of the behaviourist hypothesis, as he accepts that behaviourism does not sufficiently clarify the full scope of human learning dependent on the way that behaviourism restricts the possibility to find out about basic stimulus, reaction to connections, the environment and other principles. Another study criticizes and depicts the behaviourist educator as a person with overall control in a classroom, who neglects to connect with learners in exercises as well as involving them in real life situations. Besides, restricted interests of learners prompts discovering that higher thinking abilities are needed (Clark, 2018). The behaviourist hypothesis neglects to think about the varieties among students, with behaviourists accepting that all are of the same learning ability (Arghode et al., 2017).

The influence of behaviourism on connectivism is outlined by Carlile and Jordan (2005) as they indicate the following aspects of the behaviourism school of thought:

1. Reinforcement & contiguity

Behaviourists believe in a positive or negative feed which will stimulate a learner's response; technology on the other hand as a pedagogy under connectivism is applauded for the quick feedback it offers to learners (Ambroz & Bukovek, 2017).

2. Repetition

Carlile (2005) indicates that behaviourists believe in drill and practise as concepts, which are continuously repeated. This has influenced learning with ICTs especially in supporting low ability learners. The networks offer a repetitive nature offering multiple solutions or methods (Bourgonjon et al., 2013).

3. Variation

According to Carlile (2005) behaviourists offer various solutions to a concept. This has influenced connectivists in the sense that peer learning which is the result of networks and connections offer multiple methods of learning. Learners choose how they prefer to learn (Downes, 2019).

Barnett and Coate (2004) argue that behaviourists believe that offering rewards immediately creates an urge to continue learning. In their analysis, Das (2019) echoes similar sentiments that computer learning games enhance learning stimulus as learners move from one step to the next level, with the ultimate goal to win a certain reward. It propels continuous excitement in learning (Bourgonjon et al., 2013).

Behaviourists give more attention to a behaviour that is observable and builds its ideology on practices, which are known to be effective (Barnett & Coate, 2004). As described by Carlile (2005), repetition, the presentation of various stimuli and the sequencing of leaning content are vital to the process of learning. Connectivism through ICTs depends on ideal ordering and grouping of learning material and depends on practising and repeating of important concepts as part of reinforcement (Lopez-Perez et al., 2018).

**b) The cognitivist learning theory**

Due to the clear gaps in the behaviourist theory in the 1950s, the biggest criticism being its inadequacy to explain complex learning behaviours, the cognitivist learning theory was developed (Weegar & Pacis, 2012). The cognitivist hypothesis depicts acquisition of information being a psychological action that involves internal coding and organizing of data by a learner who is active (Masethe et al., 2017). The cognitivist hypothesis differs from behaviourism, as it centres around the psychological cycles on opening the brain to see individuals learn (Clark, 2018).

Even though the cognitivist hypothesis does not completely ignore behaviourist standards, it clarifies gaining information uniquely in contrast to the behaviourist hypothesis. The behaviourists depict information just as far as outside recognizable practices, while cognitivists see information regarding undetectable portrayals of the world sent to the brain and stored in different mental networks (Clark, 2018). The cognitivist learner is permitted to participate in learning and a cognitivist teacher encourages learning by giving numerous practical experiments (Masethe et al., 2017). Cognitivists accept that concerning learning, all children go through a similar grouping of improvement; in any case, they do this at various rates (Clark, 2018). As indicated by Stockwell (2019), learners use what he portrays to be "schemas" as the information building blocks. He characterizes patterns as the distinctive tactile engine map that the students use to build, decipher and comprehend their reality bringing about their insight advancement.

It is essential that an educator who believes in cognitivism plans his lesson and tests looking into the distinction of the exceptional distinct abilities of each learner instead of on the ordinary norm of same age of peers (Clark, 2018). As indicated by Stockwell (2019), the substance of guidance should be predictable with the improvement level of the learner, which incorporates urging educators to sort out an arrangement of new data in some unequivocal way that sets up requests in the data, as this will help learners in figuring out the new data and encoding it. In addition, the teacher can connect new information to existing information to make concepts more significant.

Finally, utilizing aids for memory like featuring, symbolism, allegories and analogies can help learners in taking care of vital knowledge, encoding that knowledge into a significant structure and recovering that information when required. Clark (2018) proposes that the cognitivist prompts the utilization of digital devices as an expansion of the human mental displaying framework. Cognitivists accept that utilizing technology can help with improving learners' intellectual ability.

The advantage of the cognitivist theory is that learners are urged to investigate instructional materials thus turning out to be dynamic makers of their own knowledge or findings (Masethe et al., 2017). In any case, a few researchers have tended to apply restrictions with respect to the cognitivist hypothesis in clarifying how the learning cycle happens. Clark (2018) gives a clarification of the principles on how the brain functions and outlines that cognitivists do not really give the adaptability expected to address singular contrasts, like contrasts in adapting needs and inclinations in preparing information. Its other constraint is that the theory enforces that a learner must achieve irrespective of whether it may be the most appropriate way for a learner to learn (Masethe et al., 2017). The cognitivist theory specifies that to accomplish powerful learning, the teacher will link the already known information to the new information. The problem could be that the technique might be challenging for under experienced teachers, as they do not have adequate experience to understand what information learners already know (Clark, 2018).

According to Donachy & Donachy (2014), the behaviourist advocates drill and practise types of learning and tasks are shaped in a hierarchical way offering instant feedback. On the other hand, cognitivists' thinking presents various methods or formats that enhance critical thinking (Stockwell, 2019).

Cognitivists argue that knowledge is gained through a natural development of one's mind as he or she engages with society. A child moves from one step of thinking to the next step as he or she is exposed to various viewpoints (Carlile & Jordan, 2005). Connectivists argue that learning happens when a learner engages with various networks, which exposes a learner to varying ideologies (Donachy & Donachy, 2014). Similarly, between cognitivist thinking and connectivism as indicated by Weegar and Pacis (2012) both ideologies advocate for deeper thinking, learners' emotions and their level of creativity and development.

### c) The constructivist theory

Mattar (2018) explains constructivism as an ideology that explains how people gather and comprehend knowledge. Social constructionism outlines those changes do not happen because of biological or natural processes (Anderson, 2018). People's backgrounds influence how meanings are formed as they engage in interactions, networks and collaboration (Vas, et al., 2018). In their review Amineh and Asl (2015), assert that social constructionism suggests that information and truth are rarely steady or widespread but instead develop as a result of social relations.

The development of constructivism was because of the behaviourists' neglect for the mental activities and the response to the way learning is described by the behaviourists (Devi, 2019). Learning is defined by constructivists as a process of building with its aim to create content instead of knowledge transmission (Guo, 2018).

Constructivism indicates a learner controls his or her learning the process. Piagetian theory (1970, 1977) influenced the birth of cognitive constructivism which emphasises that learners' knowledge creation is inspired by inner cognitive conflict as they strive to resolve a mental disequilibrium. It emphasizes that internal cognitive conflict has stimulated the learner's knowledge construction as they develop knowledge (Zhang & Lin, 2018).

According to constructivists, knowledge creation occurs due to discourses among people, comparing and debating of issues by learners and teachers.

This theory takes into consideration the guidance offered by teachers as they direct a learner through the process of a more complex knowledge creation, comprehension of concepts which will result in independent learning. It is further argued, knowledge creation is directly linked to socio-context-through open communication among learners and educators (Clark 2018).

The progression of a social constructionist theory thoroughly considers the interactions and collaboration within communities. Social constructionism speaks to and establishes a significant development in social science and the sociologies (Gentner, 2018). The primary reason of social constructionism is that reality does not exist as an even-handed and reliable setting free of human inclusion. Rather, social constructionism recommends that "reality" and our insight into it is developed in the associations among people, is based upon the experience of people, and comes full circle in aggregate understandings and shared encounters (Transue, 2013).

Burr and Dick (2017) noticed that social constructionism recommends that how one comprehends and sees the world is a result of how the world is spoken to or created through language, and relies on the way of life and times that people live in. Our insight and comprehension are consequently not supreme or lasting but are rather outlined by 'talks' which regularly mirror the thoughts of incredible gatherings in the public eye, acting to disservice less ground-breaking gatherings and people. Regardless, because talk is time and culture explicit, it can change over the long haul, frequently creating social changes (Gentner, 2018).

Clark (2018) further asserts that cognition is a joined process which according to modern constructivists, offers the theorical learning which is cooperative problem-based and discovery orientated. Constructivists believe that the learner's intelligence improves if they engage in learning interactions with their fellow classmates.

An educator who believes in constructivism pedagogy to assist learners exposes learners to learning through exploitation, recognizing of things, peer engagement and their ability to solve problems (Genter, 2018).

Constructivists assume, as outlined by Nguyen et al. (2012) that when integrating ICTs in a constructivist learning environment, learners should be able to use digital and online tools to form their own knowledge. Learning should be through active experience and exploration, which will uncover new discoveries within content knowledge and learning, should occur through social context, networking and building of nodes (Gentner, 2018).

According to Duke et al. (2013), ICT integration means methods in which learners are supported using web-based tools as they create their own knowledge in the teaching and learning context. This is further echoed by Transue (2013) outlining that digital devices allow learners to create learning community networks that assist them to build on their knowledge. Boitshwarelo (2011) links constructivism to connectivism by asserting that both advocate for digital knowledge formation, where learning is learner-centred, and educators should be able to design conducive learning environments where application directly supports content knowledge delivery and offers an opportunity for content knowledge enquiry and discovery using technological tools.

The constructivist theory advocates that a learner should create their own knowledge thereby creating new understanding by using the existing content (Bell, 2010). According to Sharp and Hamil (2018), both the constructivism paradigm and connectivity theory can enhance deep learning. This is because learning is learner-centred by developing networks, engaging and collaborating with the work. Learners further devote more time and effort to learning and developing new knowledge. They are also excited as they learn and strive to apply the attained concepts and skills. Constructivism places an emphasis on learning by building knowledge whereby individuals build an understanding of events and learn how concepts are processed, based on their personal experiences (Daguplo & Alvarez, 2019).

Through learning environments learners can share discussions and transfer data (Bell, 2010). Because of the diverse data available online, the teacher must guide learners to get relevant information. Constructivists are for the idea that looking at the quantity and quality of data at the learners' disposal, their technological competency, educators are able to guide learners through the process of learning in an enthusiastic way which has the ability to capture the interest and attention of the learners (Duke et al, 2013).

Many educational constructivist ideologists support the idea that it is an appropriate theory for the learning currently and into the future (Transue, 2013). Despite this thinking, scholars such as George Siemens, have echoed certain limitations towards constructivism theory. His criticism of the behaviourist, cognitivist and constructivists is embedded in their central idea that learning happens within a person. He indicates that although social constructivists investigate learning and socially aligned processes, it does not explain how learning takes place in an organisation (Siemens, 2006).

Constructivism happens when people create individual interpretations of their life encounters and reflect on those experiences. This ideology links with Siemens' (2005) connectivism in the sense that as learners build their knowledge through social and digital connections (Homanova et al., 2018), they reach out to networks, which are already in existence and develop new links as well. "The constructivist pedagogy is founded on the premise of creating knowledge in the learning environment supported by active learning, reflective learning, creation of authentic tasks, contextual learning and collaborative learning through networks, social interaction and digital devices" (Gentner, 2018, Keengwe & Onchwari, 2011, p. 239).

Constructivism has influenced the connectivism school of thought. This discussion will point out the similarities and connections between these two theories, and the fact that constructivism came before connectivism. One can therefore argue that constructivism had an influence on connectivism. Learning occurs through the user's manipulation, discovery and exploration of content (Zhang & Lin, 2018). Constructivists support peer to peer learning (Weegar & Pacis, 2012). Constructivists note that learning is a will to attain knowledge through one's environment, which has a direct influence on the society (Carlile & Jordan 2005). Constructivists further argue that knowledge is obtained by active participation in the learning process (Weegar & Pacis, 2012).

Constructivism is a social process attained by communication with people who possess deeper knowledge in a certain discipline (Zhang & Lin, 2018). Learning in a constructivist perspective, is a social activity where a teacher plays a minimal role and learning involves active interaction, problem-solving and collaboration with the society (Weegar & Pacis, 2012). The above is similar to the connectivism thinking as indicated in Siemens (2006). Connectivism enhances collaborative learning through social networks, and interactions are a central point of knowledge and dissemination and sharing. Constructivism and connectivism advocate discovery learning and emphasize problem-solving and learners construct their own knowledge (Zhang & Lin, 2018). In a constructivist learning environment a learner learns in cooperative groups to create knowledge, and they develop a hands-on approach which enhances discovery learning (Weegar & Pacis, 2012). This is very similar to the connectivist classroom where cooperative groups are referred to as networks as indicated by Downes (2019) or nodes which sole function is to facilitate and enhance learning and create new knowledge. It could be between humans or use of non-human gadgets.

Current learning theories were unable to provide an answer on the 21$^{st}$ century learning process. This theory has been criticised as a knowledge philosophy instead of a learning theory. Guo (2018) concurs that constructivism theory encompasses principles which are already known emanating from previous learning ideologies but it fails to add any value to the literature other than giving an explanation of the learning process (Clark, 2018).

**d) Principles of connectivist theory**

Downes (2016) states that connectivism is a theory for the computerized age which looks at learning in an ICT improved climate. From a connectivist setting, learning and information occur in several ideas and opinions, implying the number or the size of a network will influence the level of views and ideas (Siemens, 2008). Fueyo and Hevia (2018) characterize learning from a connectivist viewpoint as linking of individuals, associations, libraries, sites and other information sources such as databases, which are alluded to as nodes.

Moreover, information and learning are not attained in one area, but instead emerge from various sources sharing common interests (Downes, 2016). The other principle which connectivism accepts with regard to learning, is that learning may live in non-human devices, which might be put away and controlled by people (Siemens, 2008).

To encourage continuous learning, it is significant that associations between individuals from an organization are sustained and kept up. Information changes with time, and is always evolving or growing, in which case it is essential that the communication between individuals from a network is kept active (Downes, 2019).

The data that is accessible on the web can be overpowering. One might say that there is a plenitude of information. Nonetheless, it is significant that the individuals from a network identify connections and links between fields, thoughts and ideas (AlDahdouh, 2019). Besides, the embodiment of obtaining information does not depend exclusively on the amount of information one gets, but by utilizing the information gained to create new knowledge (Pfadenhauer & Knoblauch, 2018). The point of connectivist learning is to guarantee that the nodes can acquire precise and current information to build a new idea or invention (Downes, 2016). These nodes work through a set of networks and links that become the vehicle for knowledge formation and transmission (Altuna & Lareki, 2015; Siemens, 2006).

The following discussion gives an outline on connectivism networks and links.

Nodes refer to any subject that can be linked or connected (Altuna & Lareki, 2015), and networks are made up of a single or multiple nodes linked to formulate a relationship (Downes, 2019). The basic supposition in connectivism is that a network as an information structure has a bunch of attributes that assign it to speak to the structure of information. A network can be characterized as a straightforward arrangement of nodes that identify with one another with associations (AlDahdouh, 2019).

Methods of teaching in this theory strives to captivate a learner's attention and interest and assists them to learn more easily and obtain various content easier through the assistance of various people or sources, rather than a single source of information, and these knowledge sources are referred to as networks and connections (Altuna & Lareki, 2015). Easy access to information, and proper control of communities of learning, are the core of this theory (Aldahdouh, 2019).

"One aspect of connectivism is the application of networks with nodes and connections as a central metaphor for learning" (Mecholva & Malcik, 2012, p. 4). These are mostly derived from data, images, songs, pictures or from people (Siemens, 2005). Connectivism brings in a model of learning which embraces the idea that learning is not an individualistic activity, but it is changed through the introduction of new tools in the digital era (Downes, 2012). These connections occur outside humans; it can be amongst learners or between fellow learners, teachers and digital devices having the same interest in the concept (Downes, 2019).

**e) Critique on connectivism**

Siemens (2006) and Downes (2008) see connectivism as a theory for the information era, and even though they dismiss other learning theories, they see connectivism as a replacement to behaviourism, cognitivism and constructivism. Nonetheless, there are other researchers, who in contrast with Siemens and Downes see connectivism as a learning theory. In this manner, Bell (2010) accepts that connectivism can be portrayed more as an ideology, which guides teaching and learning in a classroom with improved digital networks, instead of being a theory. Rank (2018) sees connectivism as a degree of teaching method and educational programme as opposed to a theory as it centres for the most part around what individuals need to learn, and the abilities they ought to create to learn successfully.

The connectivist learning theory accepts that information may live in non-human apparatuses (Siemens, 2012) and be controlled by people. Nonetheless, the connectivist idea that information can be created by non-human appliances has been critiqued (Goldie, 2016). Fueyo and Hevia (2018) recognize the reason for the advancement of another theory as an interaction which expands on more established theories, without disposing of them, the explanation being that new improvements have happened which the older theories do not seem to fully address.

Jung (2019) criticizes connectivism in the light of the fact that no new ideologies can be added that are not effectively presented in other existing learning theories. The connectivist theory specifies that information dwells in a circulated way across all organizations, accepting that all learners are expected to interface, impart and share knowledge in a learning climate. Nonetheless, this idea does not take into consideration the South African schooling system, especially in township and rural schools, because of the reality that not all schools have access to digital devices or access to connectivity.

Regardless of the criticism of connectivism as a learning theory, there are other principles that contribute to connectivism as a learning theory. Connectivism closes a gap in learning in the digital world (Naidoo, 2021). From a teaching and learning perspective, learners are responsible for creating and disseminating their own knowledge using diverse digital devices. From a teacher's point of view, regardless of whether a facilitator or tutor, it may give direction to learners through approving information and probing their critical thinking (Kop & Hill, 2008).

Although there are criticisms based on connectivism as a learning theory, it portrays how learning may happen through social collaboration, which is similar to the social constructivism theory. It further explores ways to incorporate technology into teaching and learning both in and out of the classroom.

The following section investigates various ways in which ICTs can be utilized as a tool to improve teaching and learning across the globe, and for Mathematics in relation to the connectivism theory. It explains the use of ICTs in a classroom, the utilization of ICTs throughout the planet, challenges that prevent the successful incorporation of ICTs and the ability of ICTs as an instrument to improve teaching and learning.

### f) Connectivism and ICT instructional technologies

Connectivism deals with inter-connecting communities and with the available range of resources in any set up or environment particularly using the networking capabilities of information and communication technologies, thus the idea of online communities of practice becomes vital as a way of realizing connectivism in teaching and learning (Boitshwarelo, 2011). It is networked social learning (Duke et al., 2013). As he introduced this theory in 2004, Siemens believed that it simply does not make sense to view learning only as constructing information, but what learners achieve using the external networks as they learn.

The ability to be connected to various new technologies and networks enhance open learning (Yodsaneha & Sopeerak, 2013). This means that as indicated by Benedek and Molnar (2014), learners are easily absorbed if exposed to various digital learning platforms and nodes. In a connectivism classroom an educator exposes learners to a well-sequenced range of activities from various data sources (Dixon & Haigh, 2009). This is vital for progressed learners as they are thoroughly guided and there is certainty that their data sources are relevant and would enable the learner to achieve the learning goals.

Siemens (2005) and Downes (2012) further highlight that connectivism does not only talk about nodes to find information, but they also indicate that learners through connectivism are able to store and present information in various forms (Fainholc, 2008). This is very relevant to progressed learners in the sense that low ability learners should be given multiple exam opportunities (DBE, 2015) and various resources such as digital assistive devices should be used to enable their learning.

Abrams (2013) and Al-Shehri (2011) have drawn a link between connectivism and ICTs by pointing out that the implementation of connectivism depends mostly on the contemporary digital age type of classroom engagement. Anderson (2008) asserts that information can be derived in multiple sources using various technological devices. Downes (2012) says that connectivism dictates that with the teaching methodologies to be employed, the learners should be at the centre of discovering information digitally through the guidance of an educator. The knowledge building process, the presentation and storage thereof are guided through connections and networks (Greenhow et al., 2009).

The progress in ICTs and the introduction of online free resources boosts the benefits in the era of connectivism (Siemens, 2012) by indicating a move from the traditional instructional model of lesson transmission where a teacher is at the centre (Zbigniew, 2012), to a collaborate mode, which embraces and encourages communication and problem-solving and uses numerous sources of information in learning (Greenhow et al., 2012). As a learning theory, it considers the traits of digital learning environments and the online interactions (Tschofen et al., 2012).

The ability of learners to seek out knowledge through available platforms to enhance learning is connectivism (Fainholc, 2008). Downes (2012) further indicates that it is focused on the process of making relevant networks that may encompass ICT mediated learning that happens through communication with various data sources.

**g) Connectivism and teaching low ability learners**

In an analysis of students' difficulties in Mathematics, Novriani and Surya (2017) indicated that 84.6% of learners under this study showed problem-solving in Mathematics. Some of the learner participants indicated Mathematics is difficult and tedious.

Learning should not be only classroom based, cites Bell (2010), to support progressed learners, learning should extend to their daily lives. Networks should be formed which will enable learning to continue in every learner's environment and this can be attained through new digital links (Transue, 2013). Teachers play a vital task in the offering of quality education. Their methodologies in engaging with learners have a vital role in the comprehension of concepts of Mathematics and achievement (Arends et al., 2017).

In their study of 25 low ability learners in Mathematics using the repeated research design measures Machisi et al. (2021) recommend the following: to improve learner achievement, teachers should introduce learners to various methods of mathematical problem-solving rather than exposing them to one textbook prescribed method.

Teachers further indicate that there is a positive link comparing educators' teaching methods and learner performance, citing collaboration as one of the key components which affects learner performance and environmental or peer engagement. In his argument Transue

(2013) says that in a connectivism environment, an instructor or an educator assists learners to navigate and evaluate information from various connections and networks which are digital, and learning is continuous therefore it should not be restricted to one place. Novriani and Surya (2017) recommend that teachers should expose low ability learners to non-routine exercises to improve their ability to solve their Mathematical problems. They further recommend constant practise and use of multiple sources to apply various methodologies.

According to Siemens (2005), connectivism is a process where human and material sources are linked and teaching and learning occurs through connections with various data resources. This therefore suggests that low ability learners are not only restricted to one data source which in some cases may not be beneficial in achieving the set learning outcomes, but to multiple sources which may support them. In this theory, learning happens using technological devices that include a diversity of viewpoints and networks. These networks and different perspectives offer low ability learners an opportunity for drill and practise (Zhang & Lin, 2018) which assists in reinforcement of concepts. Altuna and Lareki (2015) further reiterate that through connectivity theory learners can maintain links between fields of information and it encourages deeper learning. One can therefore draw a conclusion that connectivism as a theory plays a critical role in supporting progressed learners as it opens creator-learning networks that encourages further learning and deeper comprehension of concepts.

The above review has established the following; as a comparative analysis between previous theories, connectivism has closed the gap in teaching and learning in the digital age (Siemens, 2006). Looking at the need for extra support for progressed learners and connectivism offers an opportunity for learning beyond the classroom (Downes, 2012) with multiple pedagogies which suit all learning abilities. Connectivism offers teacher-student discourse using multiple channels of teaching within and out of the classroom. Different from other theories previously explained, connectivism takes teaching beyond the classroom (Chen & Hu, 2018).

Another critical discovery in the review outlines that in the highly technological world, teaching and learning occurs in the environment depicted by excess knowledge (Yang & Wu, 2012) thereby creating multiple learning opportunities to obtain authentic and sound information. Students' critical thinking skills and problem-solving can be enhanced through the use of instructional technologies (Stephenson & Sadler- MacKnight, 2016).

Many scholars have reiterated the importance and relevance of ICT instructional technologies in the teaching and learning process, and the review of pedagogies comes into play in the digital age (Chen & Hu, 2018). Research since the 1990's investigated various pedagogies finding the comparison between traditional methods to the newly ICT instructional approaches (Nelson, 1994; Kreber, 1998 and Quintamo et al., 2009) concluding that ICT offers collaborative learning, self-instructed learning and problem-solving based type of learning.

There are however no studies especially in South Africa which investigates supporting progressed learners using ICT technologies in a connectivist classroom. As Siemens (2006) indicates, this theory expands teaching and learning beyond the classroom through the use of connections, collaborations as well as non-human digital interactions. What this study achieves is to bring in this ideology as one of the frameworks which would be used to support low ability learners using its components and thought processes.

This study will not only establish digital networks as a way of teaching and learning through ICT technological instructions, but it will specify a number of support strategies to be used to support progressed learners to catch up on missed content, understand new content and be part of the learning process which will improve their performance.

Unlike other previously discussed theories, Siemens (2005) denotes connectivism as a theory for learning which is influenced by technology and this was elaborated by Downes (2012) by indicating that in the digital age era technology is "performing certain of the cognitive operations by means of keeping or obtaining knowledge which is different from the traditional way of learning" (Chen & Hu, 2018).

What is not explained by the above reviewed studies is how instructional technologies can be used to support progressed learners beyond the traditional classroom. Secondly, looking into the South African progression policy and the ICT strategies the country has adopted, what is lacking are clear guiding principles and frameworks which give direction to the implementation of progression policy. Policy makers have reiterated the importance of supporting progressed learners and have committed the resources (Zimasa, 2016) but there are no guidelines on what entails the support strategies for progressed learners in Mathematics in FET phase. The objective of this study is then to come up with a clear framework which will act as a guideline and a reference point in supporting progressed learners both technological and non-technological.

## 2.8 CONCLUSION

From the above analysis, one can conclude that authors agree that connectivism plays an integral role in the future of learning in the digital world. "It is important to reflect on concepts such as open education, open educational resources, connectivism and rhizomatic learning environments, given that these are themes that are articulated and strengthened due to the cyber culture" (Downes, 2019, p. 122). Allowing learners some sense of control, they achieve deeper learning, critical thinking and problem-solving skills. This thereby becomes an answer to the progression theory. Low ability learners are therefore given an opportunity to determine what they learn and how they learn it. Knowledge is not only derived from a single source but from multiple sources and networks.

This study described how ICT instructional technologies and non-ICT instructional technologies are used to support progressed learners, by reviewing high performing countries.

Perron et al., (2010, p. 67) depict ICT instructional technologies as advancements used to pass on, control and store information by methods such as email, SMS, instant messages, video and online web-based media which convey a scope of data and communication platforms. The integration of these instructional technologies is vast as it incorporates a number of devices like the TV, mobile phones, tablets, PCs, intelligent whiteboards and projectors in an advanced classroom reforming teaching and learning in schools (Msila, 2015, p.1974). This change has made it a lot simpler and quicker for learners and teachers to interact, furthermore, share data from any place on the planet through the incorporation of ICT (Perron et al, 2010). ICT has further set off changes in the educational system as well as the social and financial system of individuals and countries around the world (Hinostroza, 2018). Another critical finding was, the reviewed countries did not only introduce ICT in isolation to the teaching and learning, but there was also structural support from policy to educator capacitation to curriculum streaming, to ensure that the Mathematics low performance problem is mediated.

In conclusion, this chapter gave a background of the South African and World Mathematics performance, and a further analysis was given on progression policy, its inception and how progressed learners performed in their matric examination. The theory on which this study is based was further explained and discussed in detail; its link to ICTs and its application into a classroom and its shortcomings were further discussed. The methodology of this research will be outlined in the following Chapter 3.

# CHAPTER 3: RESEARCH DESIGN AND METHODS

## 3.1 INTRODUCTION

The previous chapter gave an outline of the study's literature and the theoretical framework. It further investigated various strategies used by various countries to support learning and improve Mathematical attainment. This section gives an outline of ways in which this study was conducted. The main research question that this study aims to answer is: What strategies can be used to support progressed Grade 12 Mathematics learners?

This chapter indicates the research design and the methods of data gathering from the sampled participants. The ways in which data was collected, analysed and stored is also indicated. The research paradigm, issues of trustworthiness such as credibility, transferability, dependability and confirmability were addressed. Lastly, this study outlines the ethical considerations applied in this research.

## 3.2 THE RESEARCH METHODOLOGY

As stated by Leedy et al. (2014) the research methodology is explained as the overall way the researcher undertakes in doing the study. The following sub-sections describe the research paradigm, research approach and the research design.

### 3.2.1 PARADIGM

The term paradigm has received several explanations and interpretations by various scholars. Krauss (2005) clarifies that a research paradigm includes three components: "a belief about the nature of knowledge, a methodology and criteria for validity" (Thanh, & Thanh, 2015, p. 25), while Neuman (2000) and Creswell (2007) allude to the paradigm as epistemology or ontology, or research methods. In another analysis, Alharahsheh and Pius (2020) characterize theoretical paradigms as positivist, constructivist, interpretivist, transformative, emancipatory, critical, pragmatism and deconstructivist, post positivist or interpretivist. In the post positivist paradigm, the way of thinking is controlled by circumstances and logical results (Creswell, 2007).

A paradigm is "a set of basic beliefs that deals with definitive principles which are not open to proof in any conformist sense" (Guba & Lincoln, 1994, p. 107). This may be seen as a set of beliefs which works with a defined set of principles. Guba and Lincoln (1994) moreover assert that a paradigm is generally how the world perceives and interprets a phenomenon.

A paradigm is characterized as a belief system, world perspective, or structure that aids research (Krauss, 2005). The process of the research is efficient in that it outlines and defines study objectives, dealing with the information or data and conveying the findings happening within set systems and as per the current guidelines (Rahi, 2017).

Dow (2020) recommended three paradigms dependent on research epistemology, which incorporates the positivist, interpretive and critical worldview. The ideal beliefs have their own philosophical perspectives on how the world is seen. However, their differentiations are not generally so obvious (Rahi, 2017; Krauss, 2005). The interpretivist paradigm empowers the researcher to create a rich comprehension of a phenomenon and its existence.

#### a) Ontology and epistemology

Both ontology and epistemology make up a paradigm (Johnson & Onwuegbuzie, 2004). Scotland (2012) explains assumptions in ontology mainly dealing with what is assumed as real. My ontological assumptions negate that, what is clear is that the ways in which learners' studies varies, and teaching methods should vary to accommodate both high and low ability learners. Learners should be allowed to build their own knowledge both in and outside the classroom using available networks from digital resources.

Epistemology deals with the natural form of knowledge and is concerned with original forms of knowledge (Alharahsheh & Pius, 2020). In their explanation of epistemology, Guba and Lincon (1994) question the originality and nature of the relationship between the person who possesses knowledge and the type of information he or she has.

It further recognises relationships and networks between the researcher and the researched phenomenon to create an account of the participant's perspective, so both researcher and researched interlink.

#### b) The interpretivist paradigm

The approach of this study was according to the interpretative paradigm that is how individuals understand and interpreted their networks, create further learning communities, perceive meanings and comprehensions as they create their own ideologies of their current reality (Vandeyar, 2011). Patterson and Williams (2002) maintain that humans actively construct reality, knowledge and identities bringing in the ideology of hermeneutic principles and they can do this by obtaining knowledge from other learning communities, which according to Siemens (2005) is through the formation of connections.

Interpretivist analysts comprehend "the universe of human experience" (Cohen & Manion, 1994, p. 36). Creswell (2007) and Van der Walt (2020) indicate that interpretivist researchers find reality through participants' perspectives, their own experience, and encounters. In a minor degree, this study does not expect to explore a wide range of approaches and techniques overall; it essentially centres around the connection among interpretivism and qualitative research in the education field. The research study is based on an interpretive paradigm, as it targets identifying and describing the perspectives of teachers concerning ICT incorporation in the classroom to help support progressed learners in Mathematics.

Looking at other studies, it is perceived that the interpretive paradigm permits researchers to see the world through the views, thoughts, and experiences of the researcher. In looking for the responses for research, the researcher who follows the interpretive paradigm utilizes those encounters and experiences to develop and decipher comprehension from gathered data. Interpretivism supports researchers as far as investigating and understanding the reality of participants. Even though the interpretive paradigm is anything but a predominant model of exploration, it is acquiring extensive impact, since it can accommodate different points of view of facts. Interpretivists believe in the contextual setting in which research is based on and interpreted (Taylor & Medina, (2013).

As per Scotland (2012), interpretivism normally tries to comprehend a specific contextual setting, and the centre ideology of the interpretive worldview is that what is real is socially built. Interpretivism then again incorporates "acknowledging different viewpoints, being available to change, engaging in discourse and understanding research procedures, advancing participating in research, and going past the inductive and deductive methodology" (Scotland, 2012, p. 583). To investigate understandings of participants, an interpretive paradigm gives a setting that permits me to look at what they say about their experiences. Interpretive examination takes a more subjective than objective approach. Taylor and Medina (2013) contend that the objective of interpretivism is to give value subjectivity, and "interpretivists disagree with the possibility that subjectivity on human conduct is conceivable" (Smith & Shirnebourne, 2012, p 110).

Advocates of interpretivism do not acknowledge the presence of all-inclusive norms for research, rather the principles controlling the research are "results of a specific group or culture" (Thanh & Thanh, 2015, p. 5). Interpretive scholars do not look for the solutions for their investigations in a very rigid manner; they approach the truth from subjects, individuals who own their encounters and are of a specific group or culture. In contrast to positivists who frequently acknowledge just one right answer, interpretivism is substantially more comprehensive, since it acknowledges various perspectives of various people from various groups (Taylor & Medina, 2013).

The interpretive paradigm as already indicated, frequently looks for answers for research by framing and supporting numerous comprehensions of a person's perspective. As indicated by Willis (2007) the possibility of various points of view emerge from the conviction that external reality is variable. Willis (2007) proceeds to show that "diverse groups of individuals and various gatherings have various views of the world" (p.194). The acknowledgment of various viewpoints in interpretivism regularly prompts a more far-reaching comprehension of the circumstance (Thanh & Thanh, 2015). This will encourage the educational researcher's concrete and insightful data from populace instead of numbers or statistics.

Following from Willis' focuses, Gibson and Smith (2018) accepts that interpretivists do not believe in foundationalists, because "there is no specific right way to information, no extraordinary technique that consequently prompts scholarly advancement" (Taylor & Medina, 2013, p. 120). As per these points of view, I am gathering information for my examination from teacher participants from various educational, socio and economic backgrounds, although they share certain common themes such as teaching Mathematics in a township school.

## 3.3 METHODOLOGY

Henning et al. (2004, p. 36) explains a methodology as "a set of interlinked methods that complement one another with the ability to produce data and findings that will answer the research question and realize the purpose of the research". Holloway (2005) explains methodology as an outline of theories and principles which guide how things should be carried out and Mouton (1996, p. 35) describes methodology as "a way or method of doing something. This considers the design, setting, sample, methodological limitations and the data collection and analysis techniques in a study".

This study applied qualitative methodology. De Vos (2002, p. 36) states: "Qualitative research refers to inductive, holistic, emic, subjective and process-oriented methods used to understand, interpret, describe and develop a theory of a phenomenon or setting. It is a systematic, subjective approach used to describe life experiences and give them meaning". In qualitative methodology, a researcher engages with the selected and they describe and interpret their world to the researcher using qualitative procedures.

Merriam (1998, p. 6) cites a qualitative approach as "an effort to understand situations in their uniqueness as part of a particular context and the interactions there. This understanding is an end unto itself, so that it is not attempting to predict what may happen in the future necessarily, but to understand the nature of that setting". What it therefore implies is what the views of the teachers in such a setting are, what their lives are like dealing with such a phenomenon, and what their deeper understanding and interpretation of their situations are.

Furthermore, Bogdan and Biklen (1992) explain a qualitative data collection method as when a researcher pays attention to how things in a society have been naturally created or made, the deeper relations between content matter and what shapes the inquiry. They seek to respond to how issues which relate to how societal experiences are formed and awarded meaning (Denzin & Lincoln, 1994). Merriam (1998) further gives an explanation that qualitative research is an overarching concept that encompasses a number of forms of enquiry, which assist to comprehend and give an explanation to the societal phenomenon with a minimal disruption of its original and natural setting.

Golafshani (2003) states that it is a type of study, which obtains its results from the actual world setting with the idea of "interests unfolding naturally". Humans are natural storytellers and are socialized in societies surrounded by stories which gives narrations of who we are and our belonging, beliefs and code of ethics and principles (Bolton, 2006). Golafshani (2003), moreover states in qualitative research, findings are arrived at without using statistics. "Qualitative research basically works towards the interpretation of meanings, emotions, behaviours and/or perceptions by analysing concrete cases in their temporal and local particularity and starting from people's expressions and activities in their local contexts" (Flick, 2009, p. 30). This study will collect data using a qualitative research approach. The study considered the qualitative approach as it is further interested in the meaning individuals have created by making sense of the universe and their worldly interactions and encounters (MacMillan & Schumacher, 2010). The following analysis establishes the link between a paradigm and qualitative research approach.

Researchers accept that the interpretivist paradigm dominantly utilizes the qualitative approach (McQueen, 2002, Thomas, 2003, Thanh & Thahn, 2015, Nind & Todd, 2011). Willis (2007) attests that "interpretivists will in general support qualitative techniques, like case studies and ethnography" (Willis 2007, p. 90). As clarified by Willis, qualitative methodologies regularly give rich reports that are vital for interpretivists to completely get the contextual settings. Predictable with Willis' (2007) thoughts, Thomas (2003) explains that qualitative strategies are typically upheld by interpretivists, since the interpretive worldview "depicts a world where the truth is socially built, complex and truly evolving…" (Thomas 2003, p. 6).

The attribute of interpretivism, as far as receiving qualitative strategies to move towards the real world, stands out from the positivist worldview.

Willis (2007) further declares that interpretivists will in general support case studies; their methodologies frequently give rich reports that are vital for interpretivists to completely understand settings. The attribute of interpretivism, regarding receiving a qualitative approach to move towards the real world, is in contrast with the positivist view.

Clarifying the utilization of the subjective in the interpretive worldview, McQueen (2002) states that: "it enables the researcher to comprehend deep connections between humans to their current circumstance or environment and the part those individuals play in making the social texture of which they are a part". As reiterated by McQueen (2002, p.16), interpretivists see the world through a "progression of individual eyes" and pick members who "have their own understandings of reality". As indicated by interpretivism, qualitative techniques are receptive methods for examining reality.

Creswell (2007, p. 4) states that the "interpretative paradigm is a method for investigating and understanding of the importance people or gatherings attribute to a social or human issue". In case study research, if a researcher looks for understanding and encounters of a group of educators, qualitative and interpretivist strategies are probably going to be the most appropriate techniques. In the interpretive worldview, the urgent reasons for researchers are to get 'understanding' and in-depth data. The researcher is attentive and his or her understanding is emphatic (Punch, 2009). The above assessments of the researchers have extended my comprehension of the link between interpretivism and the qualitative approach. Following the idea of the interpretive paradigm, my study investigated utilizing ICTs as a strategy to support progressed learners in Mathematics.

Punch (2009) gives the following as attributes of qualitative study: Studies are done in their natural setting, use broad questions that are meant to enhance the participants' deeper thoughts, investigate, decipher, or comprehend the social setting. Participants are chosen through non-random strategies dependent on whether the people have data relevant to the research questions. Collection of data includes interviews and analysis of documents. The researcher strives to understand the participants' social context and the research reports information in a narrative form (Marguerite et al., 2006). The above attributes of qualitative inquiry are appropriate to my study. As a researcher, I need to comprehend the world of the participants (Cohen & Manion, 1994) through enquiring and understanding their experiences and encounters (Creswell, 2013).

## 3.4 RESEARCH DESIGN

A research design is a description of procedure for carrying out a particular study. It indicates who the participants are and the conditions under which data shall be obtained, analysed and shared (MacMillan & Schumacher, 2010). In their explanation, Creswell and Poth (2016) state that a design in research determines the statement of the overall study approach or strategy used for the specific study. It could thereby be assumed that if the research design achieves the research objective(s), it therefore most importantly guarantees that the researcher's aims are achieved. The design of the research includes the reasoning of the study theories or exploration and the research questions, while giving a thorough presentation of the research steps followed in collection, choosing and analysis of the data.

Macmillan and Schumacher (2010, p. 70) further explain a research design as "an arrangement or system which moves from the basic philosophical suppositions to determining the choice of participants, the utilization of information gathering strategies and the information about how the data is analysed and interpreted". Creswell (2014) recognised five designs underpinning qualitative research, namely, phenomenology, ethnography, grounded hypothesis, case study and biography. Considering the idea of the investigation, a descriptive comparative case study was selected to be the most appropriate research design.

### 3.4.1 CASE STUDY

There are a number of explanations given to a case study; "*A case can be defined technically as a phenomenon for which we report and interpret only a single measure on any pertinent variable",* (Thomas, 2021) while Yin (2003, p. 13) indicates that *"a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*". Creswell, (2014, p. 61) gives another perspective to a case study as studying a phenomenon which will give a detailed understanding of a case which takes into account the comprehension of an event of the social context of individuals.

Gustafsson (2017) says a case study is an in-depth study about a person, a unit or a group of people, where its aim is to offer a general view of a phenomenon. The aim of a case study as explained by Thomas (2021) is not to perform a case analysis but an appropriate way in which cases are defined or settings are described to obtain an understanding. Case studies give an in-depth description of real life, current bounded systems which are cases at a certain period using an explicit, in-depth method of collection of data, which uses several sources

(Creswell, 2014). The above views are shared by Gephart and Saylors (2020) whose definition indicates that it offers a historical view of an occurrence or idea through a certain time, applying several sources of data collection. Case studies offer a clearer comprehension of a personal phenomenon or of a society at large (Gustafsson, 2017).

According to Van Wynsberghe and Khan (2007), case studies answer to what, why and how questions, thereby making an exploration which is comprehensive. Yin (2017) refers to a case study as a tool that is utilised to comprehend various reasonings and decisions taken. It is utilised to authenticate a theory by studying a certain object, idea or social problem.

In his view, Yin (2017) asserts that a case study is an empirical inquiry, which researches a current idea in its real-life setting. According to him, a case study allows a researcher an opportunity to shed light on some theoretical principles. Yin (2017) indicates that a case study method varies; it could deal with a single case or several cases. Yin (2017) indicates that a case study can be explanatory, descriptive, or exploratory. This study wants to use a descriptive comparative case study to describe how teachers use ICTs and non-ICT to support progressed learners in Mathematics.

Case study research is comprised of a thorough investigation, dealing with information gathered throughout some period, within a certain prevailing context (Cresswell, 2014). As indicated by Yin (2017) a case study is depicted as an inquiry, which is systematic of certain events with its intention to explain a phenomenon.

According to Harrison et al., (2017), a case study research approach is basically employed to create an in-depth, original, multi-faceted understanding of a complex meaning of a difficult phenomenon in its original existence. A case study approach to research is a form of an inquiry that can be classified as a qualitative approach to research, as Opie (2004, p. 74) indicates, “a case study can be seen as an in-depth study of interactions of a single instance in an enclosed system”. It helps a researcher gain a broader perspective from participants.

Case study research could be classified as positivist, interpretivist or critical paradigms. As indicated by Opie (2004), the contextual analysis from an interpretivist viewpoint, endeavours to gain an extensive comprehension of how participants relate and communicate with one another in a particular circumstance, and how they make or create meaning out of research.

A constant criticism relating to case study methodology is that, as indicated by Harrison et al., (2017), it depends on a single case, which then makes it unable to offer a general conclusion. Yin (1994) acknowledges the idea that a case study may be “microscopic" due to the fact that “it does not have enough numbers" of cases. Yin (2003) disagrees with Yin

(1994) that the sample size does not in any way change the nature of the study. The aim of the study is to set parameters and should be applicable to all the research. This therefore means that even one case could be accepted if it reaches the set objectives of the study. When sociologists and anthropologists studied people's lives, practices and their comprehension of their societies and their cultural practices, Merriam (1998), asserts that they did such investigations within the context of their world, with a view of obtaining an insight into how they made meaning of their existence and created their worlds. Those investigations were done in their own natural surroundings.

According to Houghton et al. (2013) a case study allows a researcher to understand a specific ideology and its existence fully. It further outlines that this empirical inquiry examines a current phenomenon in its real-life existence or content, especially when there is not a clear definition between the boundaries and a phenomenon.

This study applied a comparative case study, in numerous sectors of social research, including education. Comparative case studies are an excellent qualitative technique for examining the influence of policy and practice (Bartlett & Vavrus, 2016). Comparative case studies which were developed in response to the shortcomings of traditional case study methodologies as indicated by Harrison et al., (2017), are extremely effective due to their capacity to synthesis information through location and time. The researchers explain, discuss, and show the horizontal, vertical and transversal aspects of comparative case studies in a comparative approach. Comparative case studies examine two or many incidents in order to gain more inference knowledge regarding primary source, such as how and why specific programs or policies succeed or fail (Goodrick, 2020).

Comparative case studies examine and synthesize the connections, contrasts and patterns that exist between two or more examples that have a common emphasis or purpose, in view of the nature of its research data, which was collected using a qualitative data collection method (Goodrick, 2020). The comparative case approach was suitable for this investigation since I was keen on getting deeper comparable answers concerning a particular phenomenon, which was how teachers use ICTs and non-ICT strategies to support progressed learners in Mathematics. I did this by interviewing ten teachers who employ the use of ICT technologies to support progressed learners and compared the findings with six selected teachers who responded to a questionnaire using non-ICT instructions to support progressed learners in Mathematics. Another data source was document analysis of progression policies used in the FET phase.

These participants were selected from five Ekurhuleni circuit 4 schools who teach Mathematics in Grade 12, and they may be taken as the case for this study describing their views and perceptions towards supporting progressed learners using ICTs and non-ICT strategies. This is a horizontal comparative case study as these participants share similar qualities in terms of this case; they are all Mathematics teachers, teaching Grade 12 but applying various pedagogical methods. According to Goodrick (2020), a comparative case study allows a researcher to make an analysis of the significance of similarities and contrasts across sites or programs to guide further implementation, and/or a description of the similarities and differences observed between cases to produce a holistic understanding of how the program functioned.

## 3.5 DATA COLLECTION

### 3.5.1 DATA COLLECTION TECHNIQUES

In order to acquire data for this study, three methods of data collection were utilised. The first is through the semi-structured interviews, the second is a questionnaire and the third was content analysis through progression policies used by the Department of Education.

"Interviews were used to generate data which was systematically analysed to search for themes and patterns that illustrate similarities/differences and uncover the meaning of the particular experience" (Cooper et al., 2009, p. 157). Roulston and Choi (2018) note that the implementation of interviews is very important as it details the views and perceptions of the participants within their contextual environment.

The in-depth but open-ended interviews were conducted and the questions fluid rather than rigid. Bogdan and Biklen (1992) state that with in-depth interviewing, to get information which is detailed, questions which are open-ended are the best suited types of questions to use. The second method of collecting data was a questionnaire and the third was a review of policies pertaining to progression, ICTs and educators' lesson plans. The application of multiple data gathering sources ensures that the data required is rich and authentic. The following sections give a detailed explanation of both methods that were applied in this study.

#### a) Semi-structured interviews

Interviews are a primary source of data collection in qualitative research (Adhabi & Anozie, 2017). They further describe an interview as a consultative process whereby a researcher wants to find out more about a certain issue from a certain group or participants. It is an interactive process in which an interviewer seeks information in a specific way (Witschey et al., 2013). Interviews are meant to explain the world from the point of view of the participants' experiences (Adhabi & Anozie, 2017).

Interviews are classified into three categories which are structured, semi-structured and unstructured interviews (Stucky, 2013). These three categories describe the position and power of the researcher in conducting his or her study; it specifies the degree of responsibility a researcher assumes (Harrell & Bradley, 2009). This study applied a semi-structured type of interview.

As indicated by Alshenqeeti (2019), semi-structured interviews are the most preferred in conducting a qualitative research study. Semi-structured interviews are not rigid (Stucky, 2013) and the way they are conducted centres around the participant's responses. Even though there are a set of questions, semi-structured interviews give room for the researcher to probe the participants further for deeper meaning or points of view (Alshenqeeti, 2019). Harrell and Bradley (2009) further assert that although there are questions guiding these discussions, semi-structured in-depth interviews have become vital in data collection in qualitative research. The in-depth interviews have been agreed to offer participants an opportunity to go deeper in highlighting the issues under discussion.

The interview technique that was applied in this study was both face-to-face semi- structured interviews and telephonic interviews for participants who had a concern about Covid-19 and were uncomfortable meeting face-to-face. As reiterated by Adhabi and Anozie (2017), telephonic, messenger and email interviews are increasing, reaching a large population in various regions where a researcher may not be able to go physically. During these interviews (face-to-face and telephonic) field notes were both written and recorded, and the participants' consent was obtained prior to recording.

The open-ended questions gave participants room to respond from their own frame of reference instead of following a set structure of confirming pre-arranged questions. "Open-ended questions allow for a greater variety of responses from participants but are difficult to analyse statistically because the data must be coded or reduced in some manner" (Jackson, 2015, p. 89). The line of questioning by the interviewer was logical following the respondent's answers, so that the interviewee's point of view was reliably obtained, recognized and reflected upon.

**b) Qualitative questionnaire**

This study utilized a qualitative questionnaire to collect data. Questionnaires are used in a controlled way which allows results to be inferred to a bigger population when obtained from a sample which represents a larger population (Rattray & Jones, 2007). A questionnaire is defined as a document containing questions and other types of items designed to solicit information appropriate to analysis (Acharya, 2010). According to Bee and Murdoch-Eaton (2016), questionnaires are useful for determining a population's opinions or attitudes.

Experts advise that qualitative approach, including members of the target group, be used to create questionnaire items to make sure that the information completely expresses their viewpoint and that the questions are acceptable, comprehensive and relevant to their situation (Ricci et al., 2018). The researcher used an online Google form which was emailed to the participants with a set of questions to complete. This proved to be fast and effective and was inline and adhered to the Covid regulations at the time in which this study was conducted. The response was timely, and all participants responded. Phellas et al., (2011) indicates that a questionnaire can be distributed and returned via post, email or directly hand delivered. The researcher opted for a digital Google form with a set of questions.

As argued by Kayam and Hirsch (2012), Google forms allows a person to create a survey, document, or presentation that is stored on the server and accessible from anywhere with an Internet connection. The document's or survey's security level can be altered as needed, and it can be shared with collaborators and/or participants as needed. The document can be viewed by anybody on the Internet, by those who have the link to the document or by sign-in only, with access granted by the owner. Only those who have been granted permission by the document's owner can respond to the questionnaire.

The questionnaire was structured but open ended and ambiguous opinion-type of questions were applied (Bee & Murdoch-Eaton, 2016). A questionnaire is a written document used to collect data, regardless of how it is administered. This questionnaire was organized so that all participants were asked the same questions in the same way; this is typically done with an interview-style questionnaire.

The questionnaires were self-administered, questionnaires just require questionnaire delivery; they are substantially less expensive and do not necessitate the use of trained personnel. This mode is less prone to information bias and the interviewer effect, but it has a higher likelihood of having no answer items. The major benefits of self-administered surveys are that they can reach a big sample size, cover a large geographic area, and cover a demographic that is sometimes difficult to reach (Kazi, & Khalid, 2012).

### c) Document analysis

Data was further collected from the recent departmental progression policy: National Policy Pertaining to the Programme and Promotion Requirements of National Curriculum Statement Grades R to 12, Regulation Pertaining to the National Curriculum Statement Grade R to 12, Circular E 35 of 2015 which outlines criteria for the implementation of progression in Grade 10 to 12, and Circular E22 of 2016 which is the criteria for the implementation of progression policy and Mathematics, educators' lesson plans and 2020 annual teaching plan for Mathematics. These policies offered legal guidelines dictating the procedures to be followed in dealing with progression policy.

Gorichanaz and Latham (2016, p.1118), outline using documents as a representation of a transaction between people and objects. As they explain, object analysis is "always person plus object because meaning is created through bringing and comprehending linked information from a number of sources. Documents become a part of a "multi-dimensional structure" that suggests analysis can be similarly multi-layered, focusing in various ways on individual documents, on parts of documents, and/or on the networks in which they are enacted" (Gorichanaz & Latham, 2016, p. 1129).

## 3.6 STUDY POPULATION AND SAMPLING

As defined by Marshall (1996) a population is a group identified or a set of objects that a researcher is interested in studying. Using sampling techniques is a practical and rational way of making interpretations about a larger group. The study population for this inquiry was 16 Grade 12 Mathematics educators in five Circuit 4 secondary schools in Ekurhuleni North district.

Sampling alludes to a segment of a populace or universe. Even though many consider population to just be individuals, it may be a case or things that one uses as data source in research (Etikan et al, 2016). There are two kinds of sampling techniques that can be applied in a study, which are probability and non-probability sampling (Morse & Niehaus, 2009). They characterize probability sampling as "recognizing the qualities that every unit in the population has a known non-zero possibility of making part of a sample" (Morse & Niehaus, 2009, p. 45). Etikan and Bala (2017) felt that probability sampling gives each unit a chance to form a sample, meaning that each participant possesses an equal chance of being selected.

Non-probability sampling is characterized as an examining method where there is not a choice or likelihood that components in the universe will have an opportunity to be selected for the investigation (Etikan & Bala, 2017). It restricts the quantity of participants to be considered in the research. However, it considers those who may have more influence on the research.

Convenient sampling and purposive sampling were used to select all available Grade 12 Mathematics educators from the abovementioned schools as a sample for this study. A sample as explained by Etikan et al. (2016) does not only refer to a group of people or population, it can also refer to a total quantity of cases or various things. Because population is finite, it is not possible to include all the people in a sample. As already indicated, the study used convenience sampling to select the participants.

As Etikan et al. (2016) explain this is a type of non-probability or non-random sampling. It depicts its participants by looking at how easy it will be to access them, their geographical proximity, being available at a certain given time and their willingness to take part in the study. As further outlined by Etikan et al. (2016) convenience sampling is cheaper, and it is easier to reach participants due to their availability.

I opted to work with five schools in a township located within the Ekurhuleni region. The township is Tembisa and is regarded as one of the poorer locations with a number of informal settlements. These schools are referred to as Quintile 3 schools, which means they are 100% no fee-paying schools dependent on government grants and donations from the private sector. Although the government supplies these schools with resources, there are minimal ICT resources as their allocation of resources is divided between textbooks, e-books and other digital resources. The socio-economic background of these schools is provided to offer the reader some context of the schools, because the socio-economic background has a direct impact on the application of connectivism and ICTs in teaching and learning. These are schools within the researcher's work area and to attain participants was quite easy. This therefore means in convenience sampling, those who are available and within the researcher's reach were selected.

Another sampling method used was purposive sampling. According to Etikan et al. (2016), a researcher deliberately chooses participants because of certain identified qualities that meet the researcher's requirements. The research questions guide in the selection of participants who possess such information or experience which could address the research questions (Creswell et al., 2011). Purposive sampling consists of identifying well-informed and proficient individuals who are available and willing to take part (Etikan & Bala, 2017).

In purposive sampling, only Mathematics teachers using ICTs to support progressed Grade 12 Mathematics learners from five Circuit 4 secondary schools in Ekurhuleni North district were selected. The selection of these participants ensured that the researcher acquired adequate and appropriate information required for this study. From the discussions the researcher had with the principals of the selected schools, it was noted that most of their classes have at least two educators sharing a grade depending on the size of the school. The researcher then decided to select 16 teachers who participated in the study.

### 3.7 DATA ANALYSIS

Whenever information is accumulated, the subsequent stage of the process is data analysis. Applying the qualitative method in collecting data has aided the researcher to get an in-depth view of the participants. This method as outlined by Barry (1998) assists the researcher in obtaining the participants' deeper perspectives, comprehension and their experience related to a phenomenon under study.

In order to undertake and classify data meaningfully, Atlas.ti software was employed. As indicated by Barry (1998) Atlas ti codes data and classifies it into patterns, draws similarities and creates meanings and explanations to a number of categories. "Atlas.ti offers a myriad of analytical tools that allows the researcher to quantify qualitative information through coding, data query, cross-tabulation and networked visualization of project design" (Scales, 2013, p. 1).

Data is then transcribed and organized into codes and themes. In her book, Friese (2019) indicates that Atlas.ti assists researchers to find and systematically analyse difficult concepts posed in data that is unstructured such as texts and recordings. Atlas.ti offers techniques that allow the researcher to find, code "which describes data in all its forms, it indicates the real aspects in the data in the nature of categories and the variations within each category creating subcategories," Friese (2019, p. xvii), and who interprets findings in primary data material, to assess and analyse their views to the study and check their inter-relationships.

Atlas.ti further created links within participants' responses. As described by Friese (2019) a link assists the researcher to join various entities by creating networks. In this study, Atlas.ti was used to transcribe and synchronize transcripts from participants. It assisted the researcher to further engage in generating quotations, and doing an intensive, line-by-line analysis through the writing of memos (Paulus & Lester, 2016).

### 3.8 METHODOLOGICAL NORMS

#### 3.8.1 TRUSTWORTHINESS

As indicated by Lincoln and Cuba (1985) in a research study, truth-value is established and seeks to find out if a researcher has confidence in the truthfulness regarding his or her findings and other contextual factors in which the study was done. It moreover investigates the level of confidence a researcher portrays looking into his or her methodology, participants and the general situation of the study. According to Krefting, (1991) in qualitative studies to maintain the truth-value, threats and internal validity must be considered and managed. In using the qualitative methodology, convenient and purposeful sampling, the researcher ensured that that the truth value of findings was obtained.

The idea of quality with a qualitative study depends on the inquiry methods and it is treated differently to that of quantitative research. In quantitative research, its trustworthiness is assessed by looking into validity, reliability, generalizability and objectivity (Lincoln & Guba 1985, Marshall & Rossman, 2014) and it encourages pre-determined ways for social research. On the other hand, the quality in qualitative research is often tested or guaranteed using credibility, dependability, transferability and confirmability as the criteria of trustworthiness (Lincoln & Guba, 1985, p 289 – 331) and it applies various methods to ascertain it.

Moreover, the fact that in qualitative research, a researcher may come across unplanned challenges during fieldwork, these may be addressed through pre-determined guidelines given by ethical measures (Graneheim & Lundman, 2004). Marshall and Rossman, (2014) note that qualitative research must strive to attain “truth value, applicability, consistency and neutrality”. These principles are regarded as trustworthiness in research.

#### 3.8.2 CREDIBILITY

According to Patton (1999), in qualitative research, credibility depends on three elements: a researcher needs to gather and analyse high quality data, apply rigorous techniques, and pay attention to triangulation. Another factor to be considered is the researcher’s experience and holistic approach to the research that includes his or her philosophical beliefs.

According to Shenton (2004) in order to achieve credibility in research, one must adopt appropriate and recognizable methods to conduct research. A researcher must further familiarize him / herself with the culture of participants and a random sampling of participants does achieve some level of credibility (Patton, 1999). Applications of multiple data collection methods called triangulation, and the application of interactive questions which encourage a dialogue and examining other researchers to structure the findings, can attain a higher level of credibility. A researcher must return to the participants after data analysis to authenticate the data (Guba & Lincoln, 1981) and this is referred to as “member checking”.

Credibility is how true the data is, or the interpretation of the participants’ views and how the research presents them (Cope, 2014). In order to achieve credibility, a researcher must describe his or her experiences to verify the research findings with the participants, and the highest credibility is attained if the participants’ experiences are recognized by other individuals who may also share such experiences. Graneheim and Lundman (2004) assert that credibility aims to ascertain that the original participants’ data is correctly interpreted by the researcher. For a study to be credible, as explained by Drisko (1997) it needs some level of submersion within the research to ensure that patterns and findings are verifiable. Credibility is the power to believe, and to achieve this, the researcher spent enough time studying and verifying recurrences and similar patterns within the data gathered.

Guided by the above analysis of credibility by various scholars, this study, to attain credibility, used appropriate content analysis of policies. Interview questions were semi- structured and allowed for further probing. Before conducting this study, ethical clearance was obtained from the University of Pretoria, permission was granted from the Department of Education, from the relevant school principals and consent letters were sent to participants, which outlined issues of anonymity, voluntary participation and giving the background of both the research and researcher. Lastly, the findings of the study were taken back to the participants to re-verify that their opinions were captured and interpreted correctly.

### 3.8.3 DEPENDABILITY

Lietz and Zayas (2010) explains dependability as a relationship of findings consistency. Qualitative researchers study a phenomenon in its natural setting. In this study the participants selected represented a larger sample and qualitative data collected can be obtained by another researcher. “The data collected in qualitative research is thick, rich and deep, which often overrides the preconceived attitudes of the researcher” (Bogdan & Biklen, 1992, p. 490).

Dependability moreover refers to the data consistency (Cope, 2014), this is attained if another researcher may reach the same findings as the researcher (Polit & Beck, 2012).

This study is termed dependable in an instance whereby findings were replicated with some participants with the same background. This then indicates that even if the study had to be repeated the findings would still be generating the same results. According to Cope (2014), findings should be evaluated and interpreted to ensure that they are supported by the data gathered from the participants.

Dependability is the application of "overlapping methods", (Shenton, 2004) and a thorough description of methodologies is needed to enable the study to be re-done. In order to achieve dependability, such a thorough description of methodology was done, as well as purposive sampling. Data gathered included audio recordings and field notes. Both were stored properly for audit or verification purposes.

### 3.8.4 CONFIRMABILITY

This is the ability of other researchers to corroborate the findings of a study (Drisko, 1997). As explained by Shenton (2004) measures were taken to ascertain that the findings are a true reflection of the participants' views. This is to ascertain that data and interpretation of findings are not the researchers' views or opinions but derived from the participants' data (Tobin & Begley, 2004). Shenton (2004) notes that data must be triangulated to minimize the researcher's bias. Research must also give a detailed description of the methodology to enable the integrity of the results and apply diagrams to show and audit the trial. According to Cope (2014, p. 89) "Confirmability refers to the researcher's ability to demonstrate that the data represents the participants' responses and not the researcher's biases or views".

In this study, confirmability was established by outlining how interpretations and conclusions were reached and indicated that findings were taken directly from the data sources, using direct quotes from the participants. This study ensured that data and study findings were clearly linked. To achieve confirmability, this study portrayed the findings from the participants not the views, opinions, predictions and assumptions of the researcher.

### 3.8.5 TRANSFERABILITY

Transferability means that findings can be applicable in a theory, practice or in future studies (Boateng & Amankwaa, 2016). Transferability is the level to which findings fit situations outside the study and are taken as meaningful. According to Shenton (2004) "transferability is the provision of the background data to establish context of study and detailed description of the phenomenon in question to allow comparisons to be made". Polit and Beck (2012) further explain that it is the degree to which findings of the research are transferable to other settings.

In his analysis, Cope (2014) indicates that transferability denotes that findings can be applicable to other groups. If the results become meaningful to the people who were not part of the study, and readers can compare the results with their own personal experience, the study is therefore regarded as transferable (Houghton et al., 2013).

To attain transferability, an in-depth presentation of the research findings with quotations from the participants should be presented (Graneheim & Lundman, 2004). The purposive sampling of participants and a detailed description of their responses to the semi- structured interviews worked towards attaining a high level of transferability in this study. Cope (2014) indicates that selecting relevant participants ascertains transferability, therefore the two methods selected for sampling complemented each other to attain transferability.

This research was aimed at finding information which could apply to other research with similar population samples, or yield findings which are relevant to other similar studies in nature. To maintain transferability, the researcher gave a clear complete description of the phenomenon, findings and background information to enable other researchers to make comparisons.

### 3.9 ETHICAL CONSIDERATIONS

Proper research requires considerations of ethical issues because a researcher must go to the field to collect data (Gajjar, 2013). As described by Richards and Schwartz (2002) ethics are a set of principles and values, which guide the conduct of a research. During conducting of a research study, it must be fair to the social justice, show high morals and respect and present a detailed informed consent (Marshall & Rossman, 2014). Ethical considerations are important in protecting the rights and dignity of the participants. The researcher must strive to maintain the privacy and anonymity of the participants and the right to either participate or decline participation; therefore, the research guarantees no harm to them (Busher & Natalita, 2002). Issues to be addressed in the informed consent should include according to Gajjar (2013) competence, voluntarism, complete information and understanding of the research objective.

Ethics in research or any examination has to do with not hurting or causing harm to other people in any way, being deferential to others and being reasonable to other people. Ethics has been characterized as a matter of principled affectability to the privileges of others. Being ethical restricts the decisions a researcher can make chasing after truth. Ethics say that while truth is acceptable, regard for human respect is better, regardless of whether, in the outrageous case, the admiration of human instinct leaves one oblivious of human instinct (Cohen et al., 2002).

Merriam (1998) contends that ethics difficulties in qualitative studies are probably going to arise with respect to the assortment of information and in the revealing of the discoveries. I acquired what Cohen et al. (2002) allude to as 'educated assent' which they clarify as "the methodology wherein people pick whether to take an interest in an examination in the wake of being educated regarding realities that would probably impact their choices" (Cohen et al., 2002, p. 51). This educated consent was received as a hard copy through letters routed to the participants.

The researcher indicated a concise framework of what the research was about and for what purposes the study was conducted and gave an assurance of independence and a clarification that secrecy would be kept up, particularly in the revealing of the findings.

The consent letter further indicated that participation in the research was simply intentional and that the participants could withdraw their consent at any time with no punishment or bias.

The requirements for the voice recording of interviews as an information gathering methodology also required recording of both face-to-face and telephonic interviews. The consent letters also requested permission to make duplicates of Google form responses and of learners' classwork, WhatsApp screen shots and connections or results from social media platforms that they may deliver as a component of the exercises that comprise the learning study.

It was of vital importance for the researcher to establish trust between herself and the participants. They were awarded respect and were treated as autonomous beings. They could make their own decisions which were not influenced by the researcher. Possible risks and harm were at all times examined while carrying out this research to increase sensitivity to the participants. The participants' identities remained confidential and anonymous. The study used consent letters for permission from principals, teachers and the Department of Education, and this study was ethically cleared by the University of Pretoria and lastly pseudonyms (code names) to identify the participants and their schools were used.

This study was further undertaken during the first wave of the Covid-19 pandemic. The research ensured that all Covid safety protocols, such as social distancing during interviews and wearing of masks, were adhered to. Participants' safety was the researcher's utmost priority and was clearly indicated prior to interviews.

## 3.10 CONCLUSION

My belief is that the use of connectivism in ICTs is a possible strategy to support progressed learners in Mathematics. This research explored the ideology that people understand, observe and comprehend meanings from their own interpretation of the existing reality and their environment influences their knowledge formation (Vandeyar, 2011). Their background, discourse and engagements with their society further assist to make meaning of the reality (Goldie, 2016). This link to the environment creates an understanding that connectivism and ICTs should not be used in isolation but work together to support progressed learners. The study further applied a comparative case study approach, which was an in-depth comparison of a phenomena and it used semi-structured interviews, questionnaires and document analysis to generate data.

The study population selected was 16 Grade 12 Mathematics educators and both convenience and purposeful sampling techniques were used for selection. To analyse the qualitative data, Atlas ti was used and findings were both presented in words and graphs. The chapter further established the trustworthiness of this study examining issues of credibility, transferability, dependability and confirmability and concluded by examining ethical measures which guided this study. The next chapter explores the analysis and presentation of data gathered.

# CHAPTER 4: DATA ANALYSIS

## 4.1 INTRODUCTION

This chapter focused on the analysis of data collected from the respondents. This also includes a review of lesson plans, tracking tools, annual teaching plans and policies relevant to the participants' teaching and learning. All interviews and questionnaires were transcribed to enable easy analysis (Creswell, 2014).

This section is divided into three subcategories. The first will be an interview analysis which is categorised into themes, the second is a questionnaire analysis and the third is document analysis. This comparative study will draw similarities and differences of the strategies employed by teachers who use ICT instructional technologies to those who do not and analyse learner performance through tracking tools and describe the policies pertaining to progression policy.

The analysis was based on 16 educators who participated in an interview and responded to a questionnaire in five Tembisa schools and were guided by the following objectives:

- describe how ICT and non-ICT strategies can be used to support progressed learners and their impact in Grade 12 Mathematics using connectivism theory.
- describe the type of digital networks used to support progressed learners.
- describe how connectivism theory and ICT instructional technologies can be used to support progressed Mathematics learners.
- assess the effectiveness of digital networks as support strategies teachers use.
- track the performance of progressed learners supported using connectivism as a strategy.
- describe the benefits and challenges in supporting progressed learners in Mathematics with ICT and non-ICT instructional strategies.
- compare the non-ICT strategies and ICT strategies used to support progressed learners.
- design a framework to support progressed learners in Mathematics in Grade 12.

The following questions were administered to achieve the above objectives:

**MAIN QUESTION**

How can ICT instructional technologies and connectivism theory be utilised to support progressed Mathematics learners?

**Sub questions**

- What ICT and digital network strategies can educators use to support progressed learners in Grade 12 Mathematics?
- What type of digital networks can assist in supporting progressed Mathematics learners?
- What is the effectiveness of the current support strategies on progressed Mathematics learner performance?
- What other strategies exist to support progressed Grade 12 Mathematics learners?
- What are the benefits of using ICT and non-ICT instructional technologies to support progressed learners?
- What are the challenges educators encounter in supporting progressed learners in Mathematics with ICTs and non-ICTs instructional technologies?
- How can connectivism theory and ICT instructional technologies be used to support progressed Mathematics learners?

## 4.2 PROCESS

The first set of data was qualitatively collected using semi-structured open-ended interviews and it is presented under Section 1. The second source of data was collected using questionnaires which were sent through a Google Form and the findings are presented in Section 2. The third set of data was collected from progression policies used in South African schools and this data is presented in Section 3 of this chapter.

The interviews were conducted both face to face, and telephonic due to Covid-19. The questionnaires were emailed to the participants through a Google link. With the face-to-face interviews, all Covid-19 precautions were followed; a safe distance of 1.5 meters was observed and both the interviewer and interviewee wore masks.

Introductions were made and the researcher outlined the purpose of the interview and interviewer and requested permission to record the proceedings in order to ascertain that all responses were captured. Each participant was asked 21 questions as indicated in Appendix A for interviews and seven questions were administered for questionnaire purposes as outlined by Appendix B.

## 4.3 SECTION 1: INTERVIEW DATA PRESENTATION

Table 4.1 below is a presentation of the participants' biographic data for teachers who were sampled for the interview, they will be referred to as Cohort A. The relevance of this table to this study is that experience, age and education levels influence a person's school of thought.

All the participants specialized in Mathematics, and they all teach Grade 12 and other lower grades. The number of years in the service and the teachers' qualifications played a critical role in participants' views in relation to the use of ICTs or teaching in the digital age. Teachers who taught for a very long time still seemed to prefer the traditional way of teaching, while teachers who recently joined the system and had used ICTs to study at university, seemed more comfortable and preferred to use ICTs to support progressed learners.

**Table 4.1 Teachers' biographical information (Cohort A)**

| Role | PA | PB | PC | PD | PE | PF | PG | PH | PI | PJ |
|---|---|---|---|---|---|---|---|---|---|---|
| Rank | T | T | HOD | T | T | DH | HOD | T | T | T |
| NY | 7 | 9 | 6 | 21 | 15 | 22 | 24 | 17 | 8 | 11 |
| NA Class | PM Grade 12 & 9 | PM Grade 12 & 8 | PM Grade 12 & 8 | PM Grade 12& 10 | PM Grade 12 & 9 | PM Grade 12 | PM Grade 12 &9 | PM Grade 12 & 9 | PM Grade 12 &10 | PM Grade 12 & 9 |
| HQ | BEd | PGCE | Hons Maths | HED Maths | BEd | ACE | ACE | HED Maths | BSC Maths | BEd |
| ST | Maths, Maths Literacy | Maths | Maths Acc | Maths Maths Literacy | Maths BE | Maths | Maths Acc | Maths | Maths Physics | Maths Maths Literacy |

P= Participant, T=Teacher, DH=Deputy Head, NY=Number of tears teaching, NA=Nature of appointment, PM=Permanent, HQ=Highest qualification, PGCE=Postgraduate Certificate in Education, ACE=Advanced Certificate in Education, HED=Higher Diploma, ST=Subject teaching, Acc=Accounting, BE=Business Education

Firstly, to present the results from the interviews, themes were used to set some form of structure in presenting the results. This section is divided into three themes to answer the research questions. The first theme investigated the type of ICT tools and digital network strategies teachers use to support progressed learners in Mathematics. The second theme looked at the effectiveness of digital networks, their level of usage and popularity among both learners and teachers in the sampled schools. The third theme investigated the impact of ICT instructional technological in supporting progressed learners through the use of performance tracking tools, and described the benefits of supporting progressed learners using ICTs and the challenges of using ICTs to support progressed learners.

### 4.3.1 THEME 1: ICT TOOLS AND STRATEGIES THAT CAN BE UTILIZED TO SUPPORT PROGRESSED LEARNERS

As already indicated this theme looks at the ICT tools used to support progressed learners and their availability. Secondly it presents the digital networks created to support progressed learners and their level of use and popularity. Lastly it describes ICT instructional technologies and networks used in the process of teaching and learning in a connectivist classroom setup.

#### a) Types of ICT tools used to support progressed learners at the participants' schools

All participants reiterated that the following are the most common tools they used that enabled digital learning communities or networks:

One laptop per child: All participants echoed the same view that their learners use affordable laptops that have been procured for utilization in school through government funding. These laptops are linked to the government Thutong website, which gives them access to all their relevant curriculum materials, notes, past question papers and memoranda for revision. *"These laptops can only be used while learners are at school but are not allowed to take them home",* notes Participant D*. "Due to the limited number of these laptops in other situations learners are expected to share as we have bigger numbers per class",* reiterated Participant A.

Tablets: Tablets are small personal computers with a touch screen, allowing input without a keyboard or mouse. Inexpensive learning software has been downloaded onto tablets, making them a versatile tool for learning. These tablets are loaded with curriculum materials such as e-books and past question papers for revisions.

"O*ur school was a pilot school in which the education MEC of Gauteng introduced the paperless classroom, each learner was given a tablet loaded with CAPS curriculum and each learner uses his or her own, they even take them home,"* said Participant E. This notion was further shared by Participant F as they are in the same school: "We *have laptops in classes, and each learner has a tablet which has content and they may use it anywhere."*

This view differs for the other eight participants, as their schools are not fully ICT capable. Participant A indicated that, "*our school's matric learners are also given tablets but there is a huge logistical nightmare in terms of distribution and retrieval". "Learners claim that they get stolen and getting them through retrieval at the end of the year is simply impossible"*, added Participant B, who is in the same school as Participant A.

*"Both the laptops and tablets are further loaded with e-readers. E-readers are basically the electronic tools that have a number of books in digital form, and they are increasingly utilized in the delivery of reading and revision material",* said Participant E. Participant H added by indicating that, *"not only do we get prescribed content from the e-books, we go further to download tutorials, past question papers and this can happen both at school or at home from the GDE Thutong portal".*

Interactive White Boards (IWBs): All participants indicated the availability of IWBs. IWBs permit projected computer images to be displayed, manipulated, dragged, clicked or copied. At the same time, handwritten notes on the board are saved for later use. Materials are linked to learners' cell phones via Bluetooth, and they easily save the materials taught for later referral.

According to Participant F, this saves time used for notetaking. Learners' attention is not divided between notetaking and following instructions. *"There is no need for learners to take notes, these interactive white boards are linked to learner's tablets or cell phones through Bluetooth or Share It, so it is to link the devices to take notes*. *You can also use a magic pen on the smart white boards, hyperlink content for reference to the learners' e- text books",* said Participant F.

Cellular phones: With the lack of resources, all schools have adopted a policy which allows learners to bring their phones to school, and they are linked to the school curriculum software, whereby learners are able to download lessons and materials easily. All respondents have indicated that they do use learners' cellular phones.

"*In the past cell phones were not allowed at our school because they encouraged theft and poor class concentration, but we had to devise means of how we can incorporate their use into teaching and learning and a policy was drawn up which guides the use of cell phones at school,"* said Participant G. *"With the limited resources, we adopted the use of cell phones at school with strict monitoring and regulations",* adds Participant E.

All participants shared a common view that they have allowed cell phone usage at their schools as another way to support teaching and learning with strict usage regulations. These technological gadgets are not only used in the classroom for research purposes, but they extend beyond the classroom, forming what Siemens (2006) depicts as connectivism networks. These ICT instructional technological tools are used to facilitate teaching and learning between learners and teachers, to enhance the process of learning beyond the classroom. All participants have indicated that that these tools are used to create digital networks which go beyond the normal teaching time but are further utilised to enhance support for low ability learners.

*"We use cell phones and tablets to create small study groups",* indicated Participant A.

*My colleague and I have created groups such as WhatsApp and Telegram using our tablets and we load schoolwork onto this groups",* adds F. The proceeding subsection B investigates the type of digital networks created using ICT tools.

**b) Types of digital networks created by both individual learners and educators**

In responding to the type of digital networks created using ICT instructional technological tools to support progressed learners in Mathematics, all participants indicated that there are digital and social connections created which assist and offer learners expanded opportunities and support activities. Figure 4.1 below shows the most common networks indicated by the participants in this study.

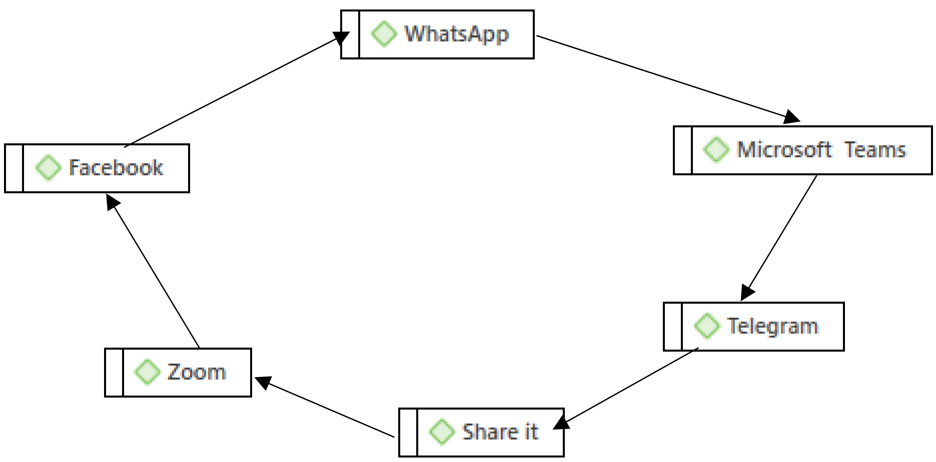



**Figure 4.1 Most common digital networks used**

All the participants indicated that the above networks are used to facilitate and support teaching and learning among their Mathematics learners.

*"With the new challenge we are facing of Covid-19, we have created small meeting platforms which translate into working groups whereby we use Microsoft Teams or Zoom to hold class discussions,"* indicated Participant C. *"For most of our interactions we have created WhatsApp groups and Facebook platforms where information is easily shared,"* said Participant J. *With the lockdown, our digital communication improved as we created a number of communication platforms such as Share it, WhatsApp, Zoom and Facebook at our school,"* adds Participant A.

Participant E on one hand indicated that, one of their support strategies was afternoon lessons that he holds virtually through Microsoft or Zoom, but the learners must be at school in order to use the smart board to interact with him. "*Even when I am absent, I use virtual devices to connect with my learners and after school lessons are most productive as there are no constant disruptions and it is small groups of learners who need support"* said Participant C.

The researcher found it important to describe what these platforms are and how they are utilised in these classes as described by the participants.

- Microsoft Teams application

As explained by Martin and Tapp (2019) this is a cloud based digital application, which conveys channels and communication between individuals in meetings designed through Microsoft 365. According to Vygotsky (1978) knowledge is socially constructed and Dewey (1938) speaks of learning engagement, active learning and collaboration which is student driven. Martin and Tapp (2019) share these beliefs that Microsoft Teams is an application which is student driven, the aim of which is to collaborate in information creation and sharing. Donnelly (2017) further asserts that collaborative learning is supported by computer devices through conversations that are seamless and shared ideas by learners in a learning community.

*"We have recently introduced Microsoft Teams meetings with my PLC where we share which methods learners understand better,"* indicated Participant A. PLC is a peer learning community where Mathematics teachers are clustered to help each other improve their Mathematics teaching skills and share best practices.

"*Our school is an ICT pilot school, so we have introduced the use of small team's afternoon lectures where learners sit in for extra hour of discussion*," said Participant F.

*"Our afternoon support sessions are sometimes done through Microsoft teams meeting application, but learners need to be at school as it is costly data wise,"* added Participant E.

*"I have introduced my learners to Microsoft teams meetings, but we do not do it quite often only when there is a concept I need to further explain, and it is for only my progressed learners because it is quite expensive*," said Participant F.

*"We use what is called Microsoft teams meetings because most of us were in Isolation and wanted to keep teaching, but we only are able to do it at school using our smart board for learners to log in while I use my laptop at home",* outlined Participant E.

Microsoft Teams, like other digital devices, use video, audio and recorded messages (Pretorius, 2018) which facilitates learner interactions. Martin and Tapp (2019) further argue that Microsoft Teams is learner centred; the tutor only facilitates the discussions. As indicated by Pretorius (2018), this is a web-based application that facilitates communication platforms developed by Microsoft. It gives users an ability to video conference, make phone calls and store files. According to participants, learners can hold group virtual discussions using this application, and those who may not be a part of this discussion may later catch up on the discussion by watching the recorded discussions on the application. Although a few participants indicated to use Microsoft teams meetings, their level of usage is very minimal due to costs.

- Facebook

Facebook is one of the most popular network platforms with the highest number of users (Bruneel et al., 2013). It enhances engagement in the digital age (Wise et al., 2011) who cited Pascarella and Terenzini (2005) indicated that learner interaction and engagement is one of the vital indicators of better academic performance. Facebook as one of the social media platforms, requires a teacher or tutor to find ways to explore its potential as a teaching instrument more than a social interaction tool (Bruneel et al., 2013). This application is an American online social media platform and a social networking service that is utilised worldwide in various languages. In this application, participants explained that learners can invite each other or follow each other and engage in various discussions. According to Participant B, this is one of the most popular applications that learners prefer to use. Learners can obtain and upload video links, post voice notes, photos and follow uploaded web links.

*"Learners follow certain Facebook group which are Mathematics aligned",* added Participant B.

*"I have recommended groups such as RB smart class to my learners to follow on Facebook"* said participant C. This is a YouTube smart class which offers extra tutorials explanations and demonstrations as explained by further by Participant C.

*"I have introduced my learners to various Facebook tutors and their support sessions are free of charge, we share and exchange ideas in our page and post various links of solutions,"* said Participant A.

*"I was shown by my learners that a lot of material for practice is posted by Facebook, so we use it a lot for exemplars*," Participant B indicated.

*"I always tell my learners that they need to check different methods and a lot of people post such solutions on their Facebook page,*" added Participant J.

*Although we do not have our own Mathematics Facebook page, we have joined several already available groups online and participate on such platforms",* explained Participant H.

- WhatsApp

Technology offers learners and teachers opportunities to interact anytime and one of the applications that facilitate such communication is WhatsApp messenger. Participant B indicated that, *"I have encouraged learners to communicate with me via WhatsApp when they are dealing with a concept they do not understand, our working hours end at 8:30 pm."* This notion was reiterated by Participant F who indicated that, *"both WhatsApp and Facebook applications were created by me and I encouraged all my learners to join these groups and we discuss complex content. I encourage them to use the platform to ask questions, seek clarity and even showcase their findings within stated timeframes". "One thing I noted was that one small group of WhatsApp where I supported my learners ended up becoming a big group of other learners some of which were not from our school, this is to show how far connected these platforms are,"* explained Participant A.

According to Ta`amneh (2017) this is a mobile application which assists individuals to network using internet data. Its uses as described by Yeboah and Ewur (2014) includes receiving and sending of messages, video links and voice notes. In a study conducted by Ta`amneh (2017) the conclusion drawn from this study indicated that integration of technology into a lesson, through applications such as WhatsApp, is more effective than using the traditional way only.

In his explanation Fattah (2015, p. 117) asserts that WhatsApp messenger is "a proprietary, cross platform instant messaging application for smart phones whereby users can send pictures, videos and audio messages." Yeaboah and Ewur (2014) indicate WhatsApp cannot only be utilized for social purposes but also be used for the purpose of studying collaboratively. This is a freeware cross platform messaging and voice platform owned by Facebook. In this application, users can make calls, send messages, videos and pictures. All the participants indicated that most of their learners have created study networks or groups using WhatsApp where they engage in discussions. Figure 4.2 below is an extract from a WhatsApp network, a discussion in Participant D's class and the second Figure 4.3 is an extract from Participant A' class.

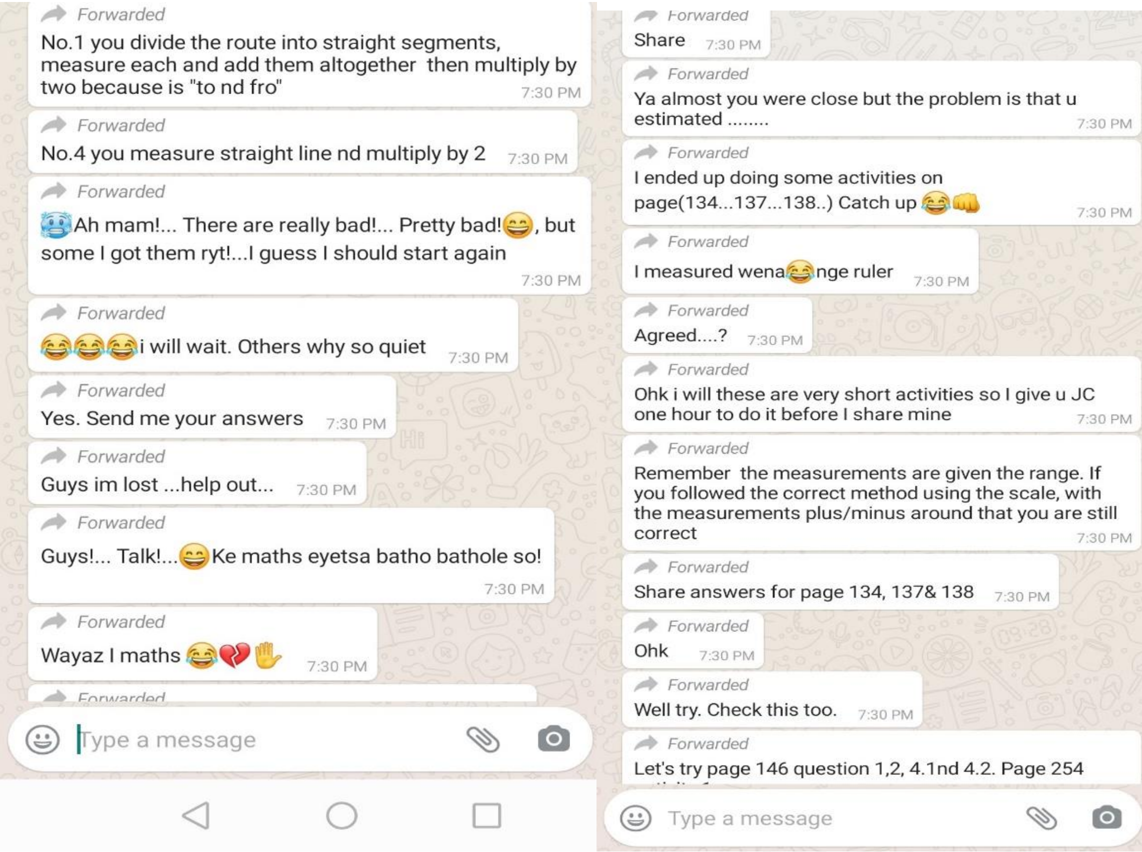



**Figure 4.2 Group WhatsApp discussion from Participant D's class**

Participant A shared her learners' Mathematics WhatsApp groups as indicated in figure 4.3 below and outlined how she uses it to communicate with this network. What was of note is the classroom rules which are firstly articulated which guides the group functionality. Secondly these groups are open for learner's input. A learner can write a solution and post it, use a voice note or send a video link.

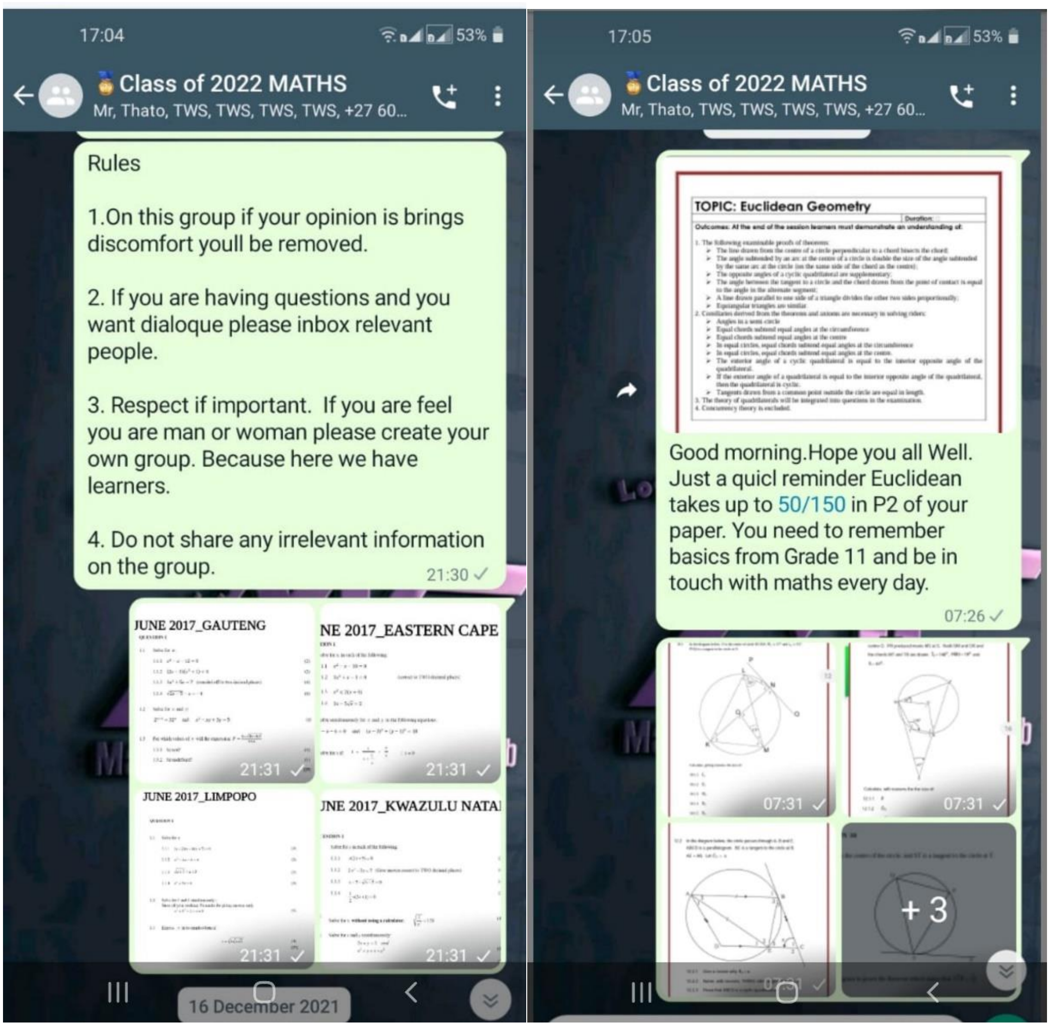



**Figure 4.3 Group WhatsApp discussion from Participant A's class**

- Zoom

Zoom is a video communication application, which allows users to use an online chat service (Martin & Tapp, 2019). Only participants A, B, C, F, I and J use Zoom meetings while participants D, E, G and H indicated that this application is not so popular among their learners and it is rarely used.

- Telegram

Satrya et al. (2016) explains that Telegram is an instant messaging application often used to send and receive messages. Telegram can further be used to communicate with digital home appliances (Satrya et al., 2016). Martin and Tapp (2019) indicate that this communication application can send links, videos, audios and PDF documents to the end user. This application was founded by Russian Pavel Durov, its distinct feature is of high security, using encrypted chats shared among its users (Martin & Tapp, 2019) and it is a freeware, cross-platform, cloud based instant messaging software and service and it offers video calling.

Learners can share files and various features. This application is growing in popularity among learners. Telegram offers unlimited storage for documents and is low on data usage. Participants indicated that Telegram could accommodate about 200 members in a group and it becomes easy to create bigger networks. Of the ten participants, eight have reported to use Telegram.

- Share it

As explained by Marange and Kariyana, (2021) Share it is a cross-sharing platform application in which users can freely share content without any cost. It requires the user to download this application to send or receive documents. Of the ten participants, nine indicated that they use Share it with their learners although they only use it when they are in their class support sessions.

*"The shared information can be used at the later stage,"* indicated Participant F. *"We share large files quickly and learners can download at their convenient time,"* added Participant A. *"My small support group usually use school Wi-Fi share solutions using Share it while at school and it is quick and is able to share very large files," said Participant E. J noted that "instead of writing extra work on the board, I just use Share it while in class for later afternoon support session discussions".*

To conclude, participants shared a common understanding that the use of connections which are applied through technological tools enhances their support strategies. As explained by Siemens (2005), connections are created between nodes, and between networks of nodes. Nodes are a representative of virtually anything, for instance a community or an individual, and the stronger the connection is, the faster information will flow between the nodes. All the ten participants who were interviewed shared the above opinion of Siemens (2005). The networks which have been created at their various schools are between educators and learners of the same school, and learner to learner networks of various schools.

Educators indicated that they load work on any digital platforms such as WhatsApp, Facebook, Share it or Telegram and send it through to the learners. "*One of the techniques I use to give learners extra work is that I send them a link with work that needs to be done at home, they are free to discuss it in the group WhatsApp for guidance or explanation",* said Participant F.

Participant C has gone further to use the design applications as sources of information: *"We share links of tutorial, videos and simulations through Share it, WhatsApp, Bluetooth if we are at school, and we explain our answers".*

It should however be noted that the level of usage, preference and ability depends on the participants' schools or learners' economic viability. The following discussion investigates the frequency of use of the digital tools within connections

### c) Frequency of use of networks

Figure 4.4 below indicates the frequency in terms of usage within the created networks at the participants' schools.

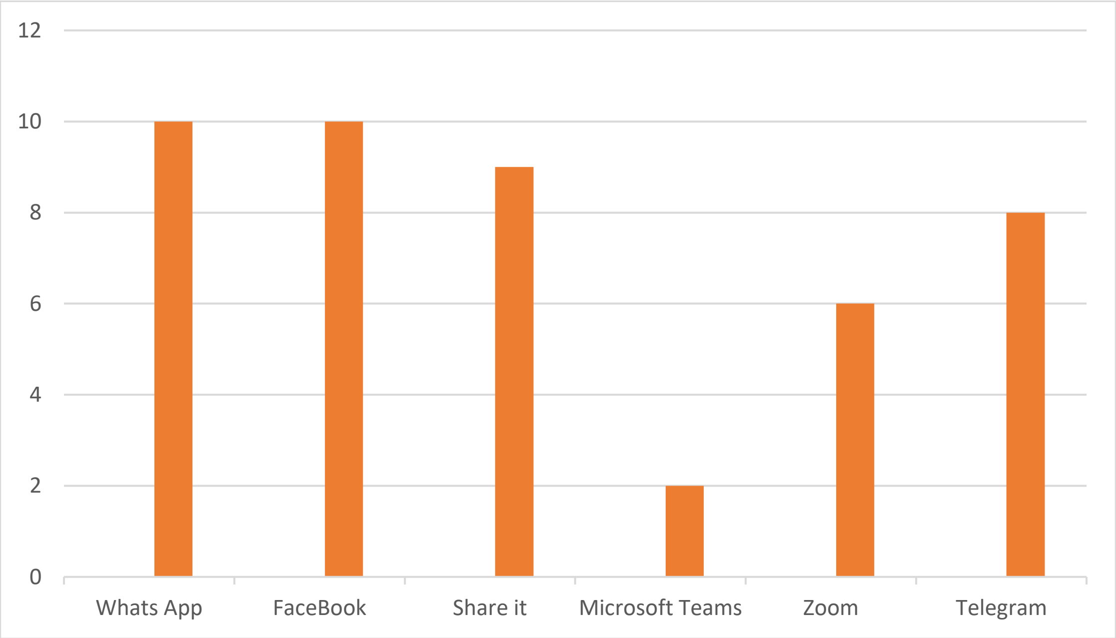



**Figure 4.4 Frequency of application usage**

Figure 4.4 above indicates the popularity percentage of the networks created by the educators and the learners. 100% (all) of the participants indicated that they use WhatsApp and Facebook applications with their learners, while over 90% of the participants outlined that they use Share it, 80% Telegram, 60% Zoom, and only 20% Microsoft Teams.

Most participants indicated that they have recently used or created connectivism networks, they have at least been using them for the last two to five years. All participants have reiterated that 2020 usage has been higher due to the Covid-19 home schooling demands. While learners were in lockdown, educators could continue with teaching and learning, and several networks were further created.

"*WhatsApp is the most popular at our school and it acts as an instant messenger",* said Participant A, while *"Microsoft Teams is not frequently used as it is very expensive, especially while the learners are at home"*, said Participant E.

Participant F noted that, "*due to the availability of school Wi-Fi, even when I am absent, I use the virtual classroom to connect with my learners through Microsoft Teams or Zoom and our daily communication is WhatsApp".*

*"My learners are responsible for so many group inventions and I just joined through the process and what works most for us is WhatsApp, Telegram and Facebook,"* indicated Participant I, and this was further noted by Participant G who said: *"With data prices, WhatsApp, Telegram and Share it are most used by our learners while Zoom and Microsoft Teams are basically used at school to connect with learners who may be absent, with technology no learner should be left behind". "Telegram works best for us and WhatsApp as instant messengers, I sent hyperlinks of their e-books and notes to explain and this work easily as learners download the content and notes and work,"* outlined Participant J.

Although the applications' popularity differs, one common response on the utilization of these platforms is that it serves as discussion platforms, clarity seeking platforms and information sharing platforms for problem-solving methods or solutions. The role of the teacher is to rectify misconceptions and give further clarity and encourage more learners to participate, and give one on one assistance privately, using either WhatsApp voice or video call or Telegram.

Another network which participants have shared is a PLC (Peer Learning Community) networks. This is a professional learning group shared by Cluster 4 teachers for each subject. All participants claimed to be a part of this network and they communicate digitally sharing best practices using Microsoft Teams for their meetings and share Mathematical content through their WhatsApp group. According to participants, there is also a Department of Education representative in this PLC to facilitate and share knowledge, common errors learners make, new methods according to research and new policies which need to be implemented.

#### d) Application of ICT technological instructional technologies to support progressed learners

The discussion above indicated the type of digital networks and connections existing in these schools and their level of popularity. The following discussion investigates how connectivism and ICT instructional technologies are used to support progressed learners in the process of teaching and learning.

Participants have indicated the following ways in which they apply technology within their networks as illustrated in Figure 4.5 below.

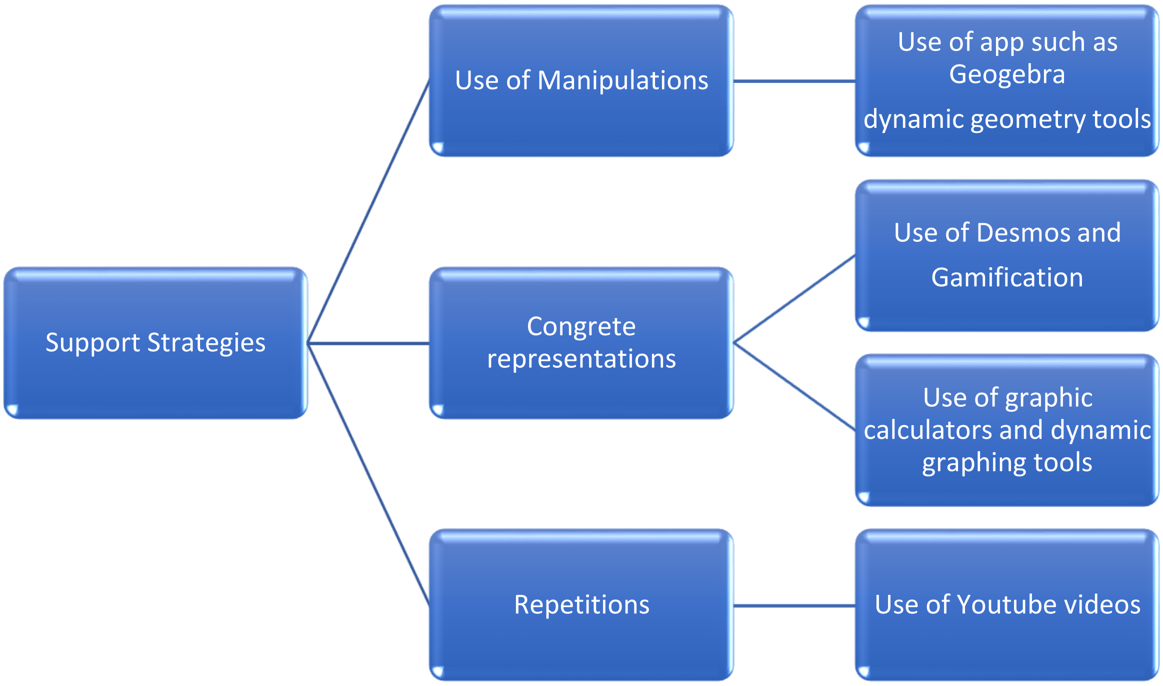



**Figure 4.5 Digital support strategies educators' use**

According to the participants, they use technology to create manipulatives, bring to life concrete objects and create repetitions for reinforcement. Participants shared a view that what progressed learners mostly require is to manipulate objects and bring them to life for easy comprehension.

The second way is through the use of concrete representation to abstract. The view that was commonly shared by participants is that technology allows them to demonstrate their lessons using concrete teaching aids such as Desmos and digital dynamic graphic tools which offers visualisation and reduces abstract teaching of Mathematics.

Another common view which was shared by participants was the use of repetitions and gamifications for emphasis. All participants agreed that repetitions allow for continuous practise, the use of video pauses and rewind build on emphasis for progressed learners to comprehend at their own time and pace. They agreed that continuous practise for low ability learners improves fluency as compared to a traditional classroom where a concept may be missed due to a lapse in concentration.

The majority of the participants noted that they use technology both in the classroom and outside the confines of the classrooms using the applications already listed. Participant A indicated that technology allows her to use manipulatives to illustrate certain concepts which may be difficult for learners to understand. She shared how she uses the Geogebra applications to teach analytical geometry. The aim of the extract from her class is to identify radius and note all the radii of the graph is equal.

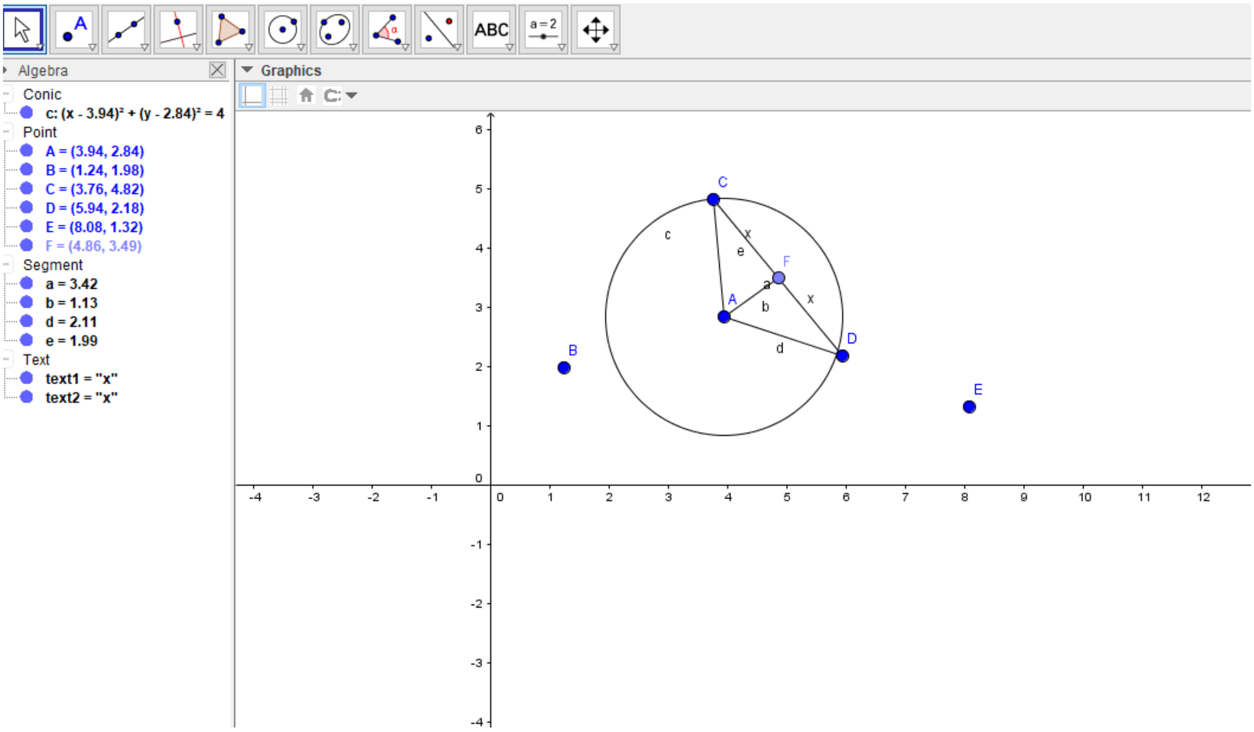



**Figure 4.6 Geogebra Application in School A**

The Figure 4.6 above was a manipulation sent to learners by Participant A and it indicates that the line drawn through the centre of a circle to bisect the chord is perpendicular to the chord. What Geogebra demonstrates is line AF will bisect the chord CD as illustrated. A circle with centre A, the chord was CD and AF bisects CD that is we have FD which will be equal to FC. This was a live demonstration which indicated the behaviour of angles for easy comprehension by the learners.

Another way in which manipulatives are used by participants was illustrated by Participant D through the use of Jamboard. This is an assistive drawing device which is interactive, and it is found on Google apps. The following JAM was sent to Grade 12 D learners through Google classroom.

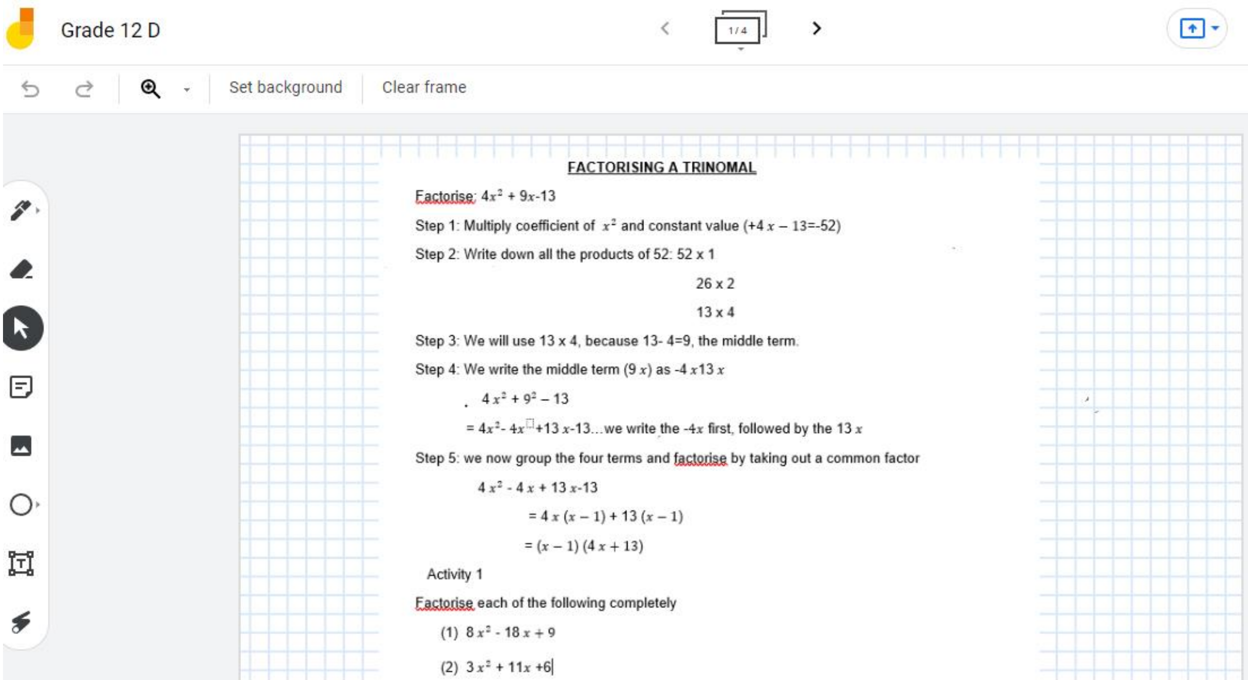



**Figure 4.7 Jamboard Application in School B**

Figure 4.7 above is an application called Jamboard, which is a Google application. According to Participant D, this application is a digital worksheet which is interactive which allows educators and learners to share, discuss and upload videos, pictures and use erasable pens. It works like a classroom smartboard but it is enhanced so that teachers and learners are able to share their work with their connections.

Participant E and F indicated that they use an application called Desmos to give a live demonstration of parabolas. Participant E gave a demonstration of how they use Desmos to teach parabolas and shared his activity which was sent to learners. The link below was a live demonstration sent to learners using a Google classroom application and some were shared via a WhatsApp link to reach a large group in the classroom. They were explaining the parabolic function using digital manipulatives and dynamic graphing tools. Both Participants E and F who are at the same school agreed that Desmos offers learners a visual illustration of the behaviour of the graph.

https://www.desmos.com/calculator/9hmpx0sb6l

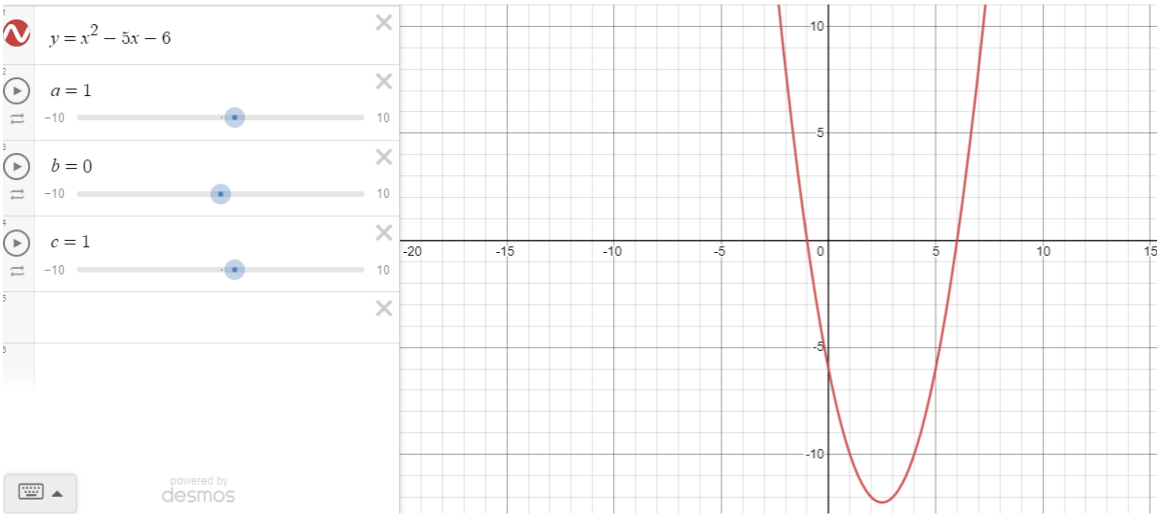



**Figure 4.8 Desmos Application in School C**

The above figures (4.5, 4.6 and 4.7) were a summary of common ways among participants of how they integrate technology into their teaching and learning to support low ability learners and this is in line with Piaget's (1970) school of thought. Participants agree that technology allows them to use concrete objects which offers tangibility, repetitiveness of concepts for emphasis, and this can be shared through technological devices among connections or networks.

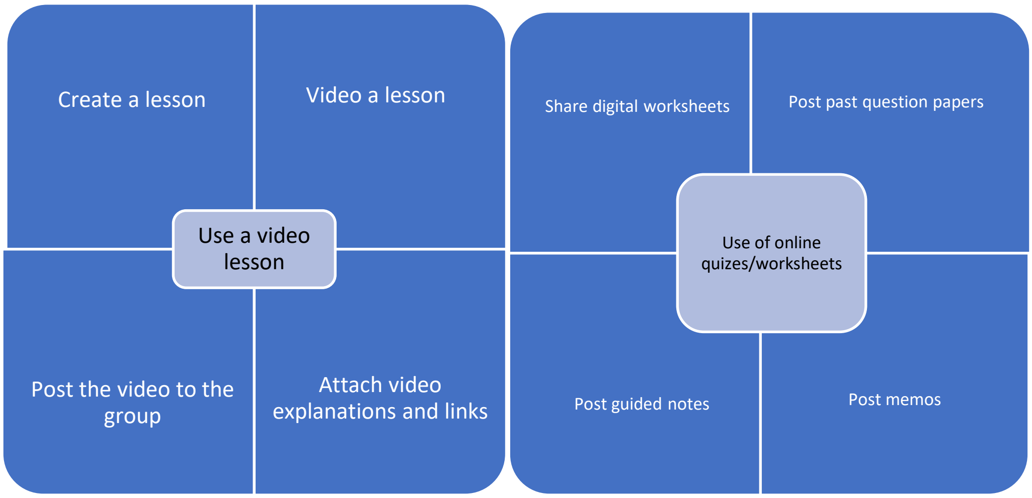



**Figure 4.9 Supporting learners with technology**

Figure 4.9 indicates a summary of participants' responses on how they support progressed learners using technology within networks. It was commonly found among participants that they embed videos, digital worksheets, quizzes, past question papers, notes and memos into their lessons then share them with their connections.

### 4.3.2 THEME 2: THE EFFECTIVENESS OF DIGITAL NETWORKS

The second theme in this study presented the effectiveness of the digital networks in these schools by tracking learner performance. This subsection further examined the effectiveness of the networks as perceived by the participants, the benefits of these networks, the impact towards the classroom atmosphere, the ICT impact towards homework and the challenges participants faced in using these networks to support progressed learners.

#### a) The effectiveness of connectivism networks formed

The above objective explored two aspects, the frequency of the usage of digital tools within networks, and in which part of the lesson teachers apply ICTs. All participants indicated that the effects of connectivism are determined by the number of learners who participate in the networks, and the relevance of the network applications in the lesson.

Figure 4.9 below indicates the estimation of learner participation within formed networks. Participants were asked to estimate at least on a scale of 100 learners per subject, how many learners actively participate within networks.

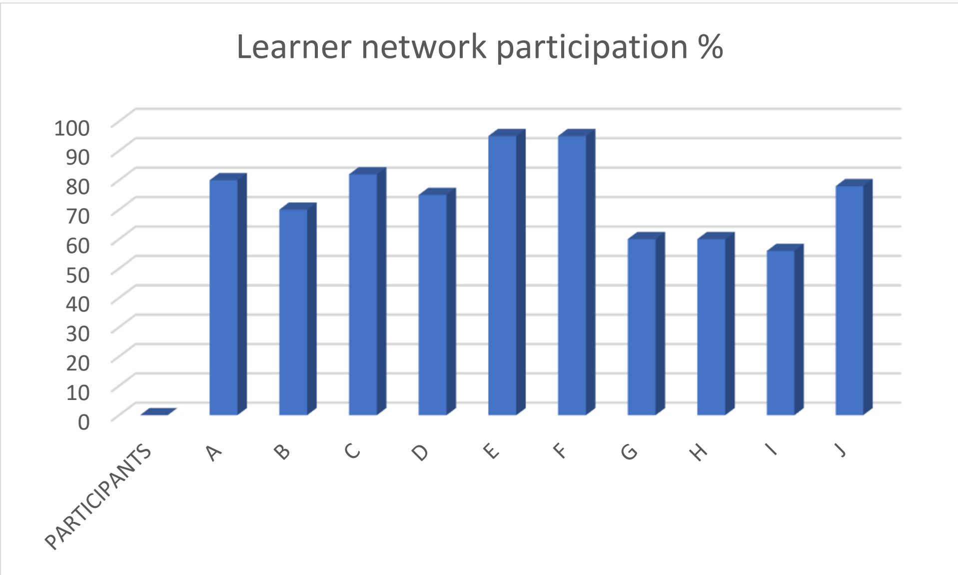



**Figure 4.10 Learner network participation**

Participant E and F indicated that most of their learners are very active constituting a 95% involvement, but they both outlined that these networks are active because the school provides learners with tablets and free WIFI, thereby making their usage very effective. Participants A, B, C, D and J indicated a range of between 70 to 80 % of their learner involvement, while participants G and H said that their average participation ranges around the 60% mark, and the lowest participating school was from participant I who indicated that only about half of their learners constantly participate. Despite the varying participation, all ten participants indicated that there are visible benefits from learners who participate in the learning networks. The participation could be through either WhatsApp groups, Telegrams, Facebook, Zoom or Microsoft Team meetings.

All the participants further indicated that the participation does not only happen at school, but also extends to after school support sessions and homework. All ten participants indicated that they engage learners after school as a support strategy, and it is mostly on a one-to-one basis or in small groups.

*"Learners are divided into small study groups which are called networks and these groups could be WhatsApp groups and they are given a concept to discuss or a problem to solve,"* indicated Participant H.

"*I was not totally responsible for all the networks and their administration, one member of the group become an administrator responsible for adding members' information,"* added Participant J. All participants agreed that they encourage all the group members to participate in the information gathering and presentation.

"*Some of these groups were personally initiated by the learners without an educator's involvement",* reiterated Participant F, making learning more learner centred. Participants E, H and J agreed that some of these links are also between learners in neighbouring schools sharing the same subject. "*We have seen our learners competing with learners from other schools using these platforms*", said Participant A. "*Learning has become one global village as our learners are further linked with their counterparts in other countries such as UK"*, indicated Participant I, who also said that their school has a learning partnership through the British Council with UK secondary schools.

Another common finding was that learners freely participate in these online discussions far better than in the classroom discussion. "*They kind of use common language to interact with their peers thereby making discussion flow easily compared to the classroom where they are restricted to use the school language of teaching and learning,*" noted Participant B. In his observation, Participant D asserts that one of the reasons for a high participation in these networks is that the learning environment created within the networks is informal, easy to follow and learners do not feel pressured to participate in the restricted time slots.

Participant C noted: "*The informal setting of these networks encourages more learner involvement".* Participant E further explained that *"low ability learners are able to privately request clarity or assistance which may be difficult in an open classroom."*

The following Figure 4.10 is the participants' response on the actual use of ICTs within a lesson outlining which part of the lesson they believe is most effective.

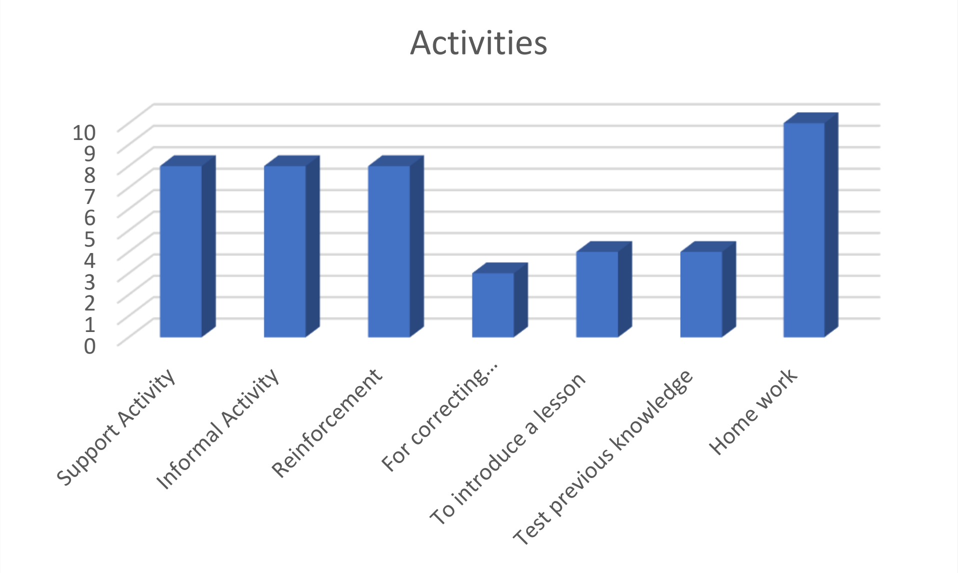



**Figure 4.11 Participants usage of ICTs and networks**

According to Figure 4.11, all the participants use ICT networks for homework purposes; eight participants use it mostly for support activities, to give informal activities and for content reinforcement**.** These are most common and popular because they extend beyond the classroom, learners work through their networks either at home or during afternoon support sessions where they link up with their connections**.**

*"This new way of learning works well for reinforcement and informal activities",* said Participant D. 100% of the participants reiterated that they give learners expanded opportunities and homework via either WhatsApp, Facebook, Share It or Telegram, and these are shared within their study networks as they extend beyond the classroom.

Only a few (about 50%) of the participants use ICTs to first introduce a concept using YouTube or a video link. This happens in class where an educator uses ICTs to make illustrations and demonstrations of a concept. *"At times learners are requested to create a video concept and make a presentation to the class to introduce a concept,"* said Participant B. *"This then kick starts classroom discussions as learners share their models or video links demonstrating different methods which could be applied in solving a certain problem,"* Participant A further explained.

Participant H indicated that, "*I use it to capture learners' attention and interest to initiate further research; this prepares them for the next lesson on the following day".* This method was further outlined by Participant E who indicated that, *"through the use of YouTube videos, I introduce most of my lesson to provoke critical thinking and probing questions".*

All the participants indicated that connectivism when used in conjunction with ICTs allows for interaction and collaboration outside the classroom. "*Teaching and learning has become continuous even after school",* said Participant H. According to Participant B, D, F and G, learners collaborate with a larger group of other learners from various schools to share notes, video links and study materials. *"There is a continuous interaction through the use of social media platforms which enhances teaching and learning*", said Participant A.

**b) The Impact of ICTs to support progressed learners using connectivism theory**

Numerous educators who were interviewed by Zimasa (2016) published in the Daily Vox indicated a concern towards the progression policy. They generally argue that these learners contribute to a high failure rate in higher grades. This view was commonly shared by the participants in this study, but they indicated that the introduction of ICTs and connectivism have resulted in more benefits than challenges.

*"The social network groups helped me to easily reach my progressed learners in their private space and they help each other,*" indicated Participant D.

*"Most of our groups are online groups formed by using WhatsApp and assists me in supporting my learners,"* said Participant B.

"*Our Facebook platform has a number of followers who share different methodologies and solutions when addressing concepts. You find not just my school but learners from other schools,"* outlined Participant A.

*"These groups are personalized, and my learners are very in seeking and sharing knowledge from either websites or their WhatsApp group,"* added Participant F.

"I find online groups very effective because they offer cross reference and differentiated learning," explained Participant H.

*"I like how my learners discuss in these platforms, even shy learners are free to participate*," said Participant I.

*"Learners love technology, they easily research and share information among their small study groups, and I like it because it has made my class very interactive,"* indicated Participant E.

*"Certain apps such as Geogebra, makes teaching Mathematics easier because it concretely gives demonstration,"* said Participant A.

*"There is an app called Desmos which is a good teaching and digital worksheet which assist in teaching and reinforcement to further understanding*." said Participant F.

*"Digital worksheets such as Jamboards act as teaching aid supports these learners because they offer a sense of gamification,"* added Participant E.

One of the common responses was the improved concentration level. According to Participant D, the pause and rewind features offered by video lessons allows for an improved concentration level.

Participants indicated that instructional technologies enhance learner-centred learning which in turn encourages full participation and allows for group work, which thereby encourages peer assistance that is beneficial to those learners who are unable to participate in a class. Participant D added that learners are able to help one another, and they relate easily in these study connections. "*The social network platforms have opened doors for learners to be able to reach out to high ability learners or a teacher to seek clarity or further explanation,"* explained Participant F.

According to Participant H, I, J, F and D, connectivism has given rise to the cooperative learning technique among both high ability and low ability learners. This allows learners to learn from one another and obtain vital interpersonal skills. "*The goals of cooperative learning are to improve learners' learning and to develop their social skills such as decision-making, conflict management and communication skills,"* as indicated by Participant H.

*"This type of teaching method offers opportunities for higher order thinking compared to passive listening, it further enhances paying attention to others and offers room for instant discourse and feedback and adjustment of thought,"* echoed Participant C. All participants shared a view that learners are able to help each other in comprehending content and this may assist them to widen their viewpoint on issues or understanding of issues. "*It is common for learners to assess the ideas of peers, to check if they relate to their own thoughts and ideas. Either they disagree or not which ultimately results in the formation of new knowledg*e," notes Participant H.

Downes (2016) outlines that connectivism allows a community of people (working with learning technologies) to legitimize what they are doing. Educators can expand the application of social media to refine and spread knowledge more quickly through membership of multiple learning communities. Participant D explained that "*this platform has allowed progressed learners to go through all the discussions at their own pace looking at various viewpoints and this to some extent assists them in understanding concepts which may not have been clear or are too difficult*". The use of the digital devices in this community of learning encourages a flow of knowledge quicker to a widespread community, not just within a single school, but also within the whole district depending on how large the network is, indicated Participant C.

All participants echoed that the use of ICT instructional technologies in a connectivism classroom model encourages flow of knowledge between numerous participants. Participants A to J claim that using ICTs in connectivism encourages a rapid pace of information development and decentralization. "*Learners are exposed to new and relevant information at all times*," added Participant A.

Participants further agreed that it encourages a variety of solutions / methods in a problem-solving situation thereby making learning and teaching more learner centred. "*This gives progressed learners more options,*" said Participant F. Learners learn at their own pace, especially progressed learners who experience time challenges in a classroom where lessons are time bound. "*With the highly loaded CAPS curriculum and the classroom pace, these platforms act as a form of reinforcement which are very beneficial to progressed learners,"* explained Participant C.

All the participants shared a view that connectivism helps progressed learners to have access to the sources immediately while learning in the comfort of one's own environment such as home. Participant D indicated: "*It further encourages virtual and remote learning*". Participant B added that it has further assisted during lockdown learning. Learners who were under quarantine were able to access schoolwork, do it and submit it at the same time as learners who were at school.

According to all participants, when ICTs are used in connectivism, it encourages and improves learning flexibility. It further fosters creativity and collaborative learning. As indicated by Sahni (2016), all participants agree that connectivism plays an important role in learning to learn. Learners learn effectively and it opens the learning opportunities and platforms both in the formal and informal set-ups.

All the participants shared a notion that one of the purposes of the above networks is content development and data sharing to assist progressed learners. All five schools use IWBs, which are linked to learners' Bluetooth devices. Learners can access the current content and disseminate it to their groups or use the notes for reference at a later stage. "*The ability to digitally take notes and share it with other learners has made teaching and learning more effective especially for progressed learners,"* notes Participant A. Naidoo (2021, p. 93) asserts that "*ICTs hold much promise for use in curriculum delivery as a pedagogy and it has a potential to improve teaching and learning capabilities and improve learner performance*".

**c) The benefits of using ICTs in connectivism networks to support progressed learners in Mathematics**

It was previously indicated that this theme will also look at the participants' views of the benefits of using ICT networks to support progressed learners in a connectivist set-up. This was done through the description of the participants' views and tracking of the progressed learners' performance.

The following analysis was stated as perceived benefits of using connectivism and ICTs to support progressed learners. All participants shared the following views:

- ICT supported lessons are simpler and easy to administer.
- Various methods are uploaded and shared among the learners that makes teaching and learning easier especially with low ability learners.
- Learners then have a choice to follow their preferred method of solving any mathematical problem other than where they are forced to use one method that an educator prefers.
- Lessons are more learner-centred and discussions are broader in these digital learning groups.
- Learners have the responsibility to learn from each other, share ideas and research better available solutions to various problems. "*This encourages peer learning*", echoes Participant A.
- Rewind and pause offer drill and practise for reinforcement.

Moreover, participants indicated that connectivism encourages student engagement not only amongst the learners and the educators, but also with the applications and resources they find online. This happens when learners engage in ICTs for research purposes. Most participants indicated that learners find a lot of information in online platforms, and their role as educators is to correct some of the misconceptions they might find in this kind of information. Participant A, B, D and F indicated that many Mathematical solutions are found as learners engage with various apps in which they share.

Most participants agreed that it encourages interaction and collaborative learning. Learning in the connectivism ideology allows learners to collaborate and assist one another, so teaching is no longer traditional, solely dependent upon the educator to come up with content. Content is created by learners and shared among learners from various websites and tutorials. "*One small concept is thoroughly researched, and learners come up with varying methodologies which they together collaborate into one acceptable presentable concept",* noted Participant C. "*Learners do not only depend on each other as information sources, they refer to multiple sources on the internet and this opens up a bigger learning platform",* said Participant F.

All participants shared the notion that connectivism and ICTs allow revision and cross reference by learners. "*Information does not only reside with humans, but can also be obtained from digital devices*, says Participant F, so these systems give learners an opportunity to refer back to what was discussed in their own time and pace. It allows them to ask clarity seeking questions on different platforms and obtain varying views from their peers and this view was commonly shared among the participants.

Another benefit highlighted was that learning becomes continuous. *"A learner controls when to learn and what time he or she spends on a concept",* said Participant D. *"One of the common observations with learners who are progressed is that they take time to understand a concept, so continuous learning assists them to fully follow the discussion until they comprehend a concept,"* said Participant D. "*It allows easy communication; learners prefer to use their mother tongue in small learning groups or informal language which they all understand,"* indicated Participant I.

Another common finding among most of the participants is that learners can catch up on missed content and revisit complex content in preparation for examinations. "*These networks act as revision groups even during examinations,*" noted Participant B. Participant J added that *"information freely flows among the participants and learners use these platforms as reference points.*" All participants shared the notion that it further allows learner participation at their own comfortable pace, uses different modes of communication such as sound from videos, demonstrations from tutorials and the use of colour and pictures acts as support tools.

"*Social networks are not only meant for social engagement*", said Participant G, "*they are also a huge library which contains a lot of resources,"* indicated Participant C. Participant F explained that: "*Learners find videos and tutorials which have practical demonstrations, and these acts as extra support for progressed learners"*. Participant J explained this notion further by saying: "*What happens in this network is learners do their own research online, share their findings and a learner can compare different findings and comprehend the best methods to apply"*. "*In this process learners develop research skills, and this is a vital learning skill which learners could further apply in their process of learning*", explained Participant A.

Teaching Mathematics has evolved with the use of ICTs. All participants indicated that they use Mathematics-friendly applications such as Geogebra, some use Jamboard and Desmos applications to teach. "*The Geogebra app is a practical way of bringing abstract Mathematical concepts to the learners for their easy comprehension especially progressed learners,*" outlined Participant F. Another common concept participants use are YouTube video links, which they send to the learners and share among their study groups, which give demonstrations of various concepts.

Rabah (2015) indicated that when incorporating ICT into teaching and learning networks, the benefits are improved performance and learner interest, and learner participation is enhanced. Participants A, B, C, D and I shared the same views, namely that the attention span of the learners is improved. "*Learners are able to find well-researched content,*" said Participant D. "*Learner autonomy is encouraged,*" indicated Participant A. *"Learners learn in a co-operative way as they obtain individualized content aimed at their specific needs and a learner's level of participation is increased*", highlighted Participant E. "*Instant feedback offered by ICT acts as reinforcement and correction of misconceptions",* indicated Participant C. "*I have observed an improvement in marks,*" said Participant I.

ICT in the digital era has further changed the educational atmosphere in numerous forms, which includes the teaching setting and teaching resources employed in the classroom (Floris, 2014). This notion is shared by Participants F, A and C, that learners can learn in the comfort of their homes and are able to choose their networks which may consist of people they are comfortable to learn with or learn from. This according to Participant C, is "*a safe space for learning where low ability learners are most comfortable to express themselves; make errors without fear of being ridiculed*".

All participants shared Van Niekerk (2009)'s view that ICTs within a connectivism ideology has also offered room for personal growth. It opens doors and access to knowledge beyond the classroom. "*Learners get instant feedback from each other*", indicated Participant D. It also promotes deep learning and enables teachers to respond to learners of different abilities (Lau & Sim, 2008). "*It further replaces the traditional way of teaching and learning where knowledge resided only with a teacher*, echoed Participant E.

All participants shared the most common support strategy; that they find and select support materials and upload them for learners who require support for revision purposes. In his view, Participant J indicated that, "*these materials not only benefit low ability learners but are shared among various networks as part of their revision."* Participant F explained that *"with the wide range of teaching and learning materials available for free on the internet, teachers can select those that suit the students' needs according to their level and abilities"*. *"ICT accommodates all learner ability",* asserts Participant A. This therefore means that ICT instructional technologies have an ability to cater for progressed learners as well as low ability learners (Bradshaw & Stratford, 2010), while connectivism connects most learners.

ICT instructional technological tools enable teachers to synchronize their efforts and realize the classroom needs in the modern technological world (Mampane, 2017). Participant A, B, C, D, E and H assert that ICT-based learning success depends solely on the attitude of a class teacher who will positively affect how this practice is incorporated into teaching and learning. This view was further echoed by Participant J as he outlines that, "*I identify my progressed learners' needs and guide them to the websites where they can find the correct information and encourage them to find solutions or create more knowledge and share it among themselves".* These networks are very comfortable spaces for these learners, therefore there is no pressure of memory related questions where they are forced to recall what was said. They are solely responsible for the information they obtain and check with the teacher whether that information is acceptable or not, indicated Participants C and D.

All participants further indicated that they are a part of the network which learners have formed in order to facilitate the discourse and correct misconceptions. This ideology has further been reiterated by Donnelly (2017) as he explains that employing ICTs for learning has proven very effective in schools in India and has bridged the educational divide between high ability and low ability learners, but it requires educators' monitoring.

Participant A, B, C, F and G assert that, learners can find new knowledge on their own and present it to their networks. *"The role of a pupil is thus progressively changing – from them being passive containers, which must be filled with knowledge, to an active participant of the educational process, who creates their own knowledge and surrounding reality."* (Participant

A). "*We use virtual worlds to teach complex topics, when one travels into the virtual world, it becomes easier to understand a difficult concept which is simulated by such a game",* said Participant J. Most participants noted that more knowledge is discovered within the networks as they allow instant research, which is not the case in the classroom setting.

All the participants agreed that there has been a positive outcome from the networks as it encourages more of peer learning and learner engagement. In their research study, Ketelhut and Schifter (2011) assert that one of the educational benefits of teaching with computer approaches is that they give a good platform to engage learners with their own activities, which has a potential to yield positive educational results. "*The idea of images, colour and instant feedback offered by these applications make learners want to engage further and some applications even give rewards in the form of points to move to the high level of a practice; this on its own motivates these learners to want to explore further and use ICT as their information source*", said Participant E.

All participants further agreed that ICT learning approaches build on many learners' existing interests, skills and knowledge and can reduce the gap between home and school cultures. "*Some of these designs are learners' creations and they present them to their fellow classmates",* highlighted Participant B. Roblyer and Doering (2012, p. 363) further highlight that "the use of ICT tools in the classroom and outside the classroom is important in creating effective learning experiences, since they are aimed at engaging various senses of the learner". This means that over and above the teachers' class discussions and engagements, learners should be able to explore alone in their community of learning as they collaborate and share ideas.

As echoed by Participants E, F, A and B, ICTs have become a vehicle for learning as it provides many opportunities and allows limitless learning which expands beyond the classroom, repletion, drilling and instant feedback. Mustola et al. (2016) share this view that learners are excited about navigating the digital fantasy world while learning and sharing their new knowledge.

All the participants share Shaffer (2006)'s point that ICT based learning gives learners an opportunity to creatively operate a world of thoughts; they can reach originality and discover new inventions. "*These learners come up with new exciting inventions, solutions and methods which assist other learners to thoroughly understand various concepts,*" Participant B noted. "*It encourages innovation and creativity,"* added Participant F. These are qualities that are very significant in today's technological competitive world. This view is further supported by Prensky (2003) who believes that ICT offers different instructional strategies and that digital networks get learners to participate fully, improves interest and the zeal to achieve.

"*They are not passively discussing, rather they engage in building models and participation in virtual worlds as they construct knowledge",* indicated Participant F. *"Comparing ICT used in pedagogy with traditional approaches, teaching with ICT offers a more social and cultural world which enables learners to model their thinking to match societal interactions",* echoed Participant H. All participants indicated that learning has extended beyond the classroom due to the networks which have been created. It has encouraged remote learning and educators' accessibility to learners whenever they require extra support.

Negoescu and Boştină-Bratu (2016) assert that a textbook is no longer sufficient. "*We have e-books which are loaded with CAPS content and learners are no longer expected to buy textbooks as they are on their tablets*", indicated Participant C. *Every year the Department of Education incorporates supplementary resources, modifying content, creating visual illustrations using ICT tools*, Participant H indicated. Participant A, B, C, D and J highlighted the effectiveness of using the Geogebra application and gadgets such as magic pens as a support. Dumford and Miller (2018) point out that new technologies firstly support teaching and learning, then extend and finally transform pedagogy as teachers slowly explore the depths of ICT ability.

All ten participants shared the same view that the creation of networks has enhanced communication among learners. According to Downes (2012), peer to peer education has been proven very effective. Learners can share ideas, recall, research and share their findings digitally while the educator's role is to guide the discussions and correct the misconceptions. This is done in study groups, WhatsApp groups and other digital platforms used to enhance these links. Although it was noted by Participant F that certain data sources are not necessarily authentic, nine participants were of the view that the networks created provided stable knowledge which could be used in the classrooms.

Six of the ten participants indicated that due to the evolving technology, they too must do thorough research to keep up with the changing technological demands in order to keep up with the class discussions. *"Some of the learners' findings at times are very new concepts which as a teacher I also need to learn*", said Participant B. This means teaching has become mostly learner orientated. It was further reiterated by all participants that the role of an educator is to ensure that he or she corrects wrong information and keeps the networks stable and productive.

*"Certain learners take the learnership roles to maintain these links and ensure that the flow of information is properly managed"*, outlined Participant A. *"The educator facilitates the flow of information while rectifying misconceptions and errors"*, added Participant C. "*The group administrators are learners, and they automatically take up a leadership and responsibility role to ensure the functionality of these networks*", Participant J explained. One of the common responses among the participants was that some of these networks were informally created; they are self-updating, and they keep growing as more learners make requests to join the study groups. "*We had to join these platforms as these learners had seen their importance*", said Participant G.

**d) Learners' reaction towards learning with ICTs and connectivism**

According to Participants B, D, F and G, without viable joint effort among learners and teachers, learners regularly lose inspiration because of the apparent absence of networks and feeling of shared learning. "*Progressed learners do not naturally participate in a traditional learning set-up for various reasons, but these platforms have offered some a safe space to engage at times privately with me,*" indicated Participant A. This view was further shared by Participant C who outlined that "the *level of participation has improved in discussions and engagements through these platforms far better than the normal class discussions*".

Participant D further asserts that *"these platforms have encouraged even shy learners to take part in engagements". "I encourage them to participate, challenge them with extra work and their interest has increased,"* indicated Participant G. *"This is a safe space for them to study and they have indicated privately that they feel included and seen in these platforms,"* adds Participant J.

Another issue which was constantly raised by participants is the improved learner attendance due to the introduction of ICT into their schools. "*Some of these learners are more interested in the design processes and will never miss these lessons*", indicated Participant E. "*Our classes are always full because these learners enjoy exploring concepts using ICTs*", said Participant F. "*It has further increased interest and this I see through participation in online activities,*" added Participant H. "*I track those who are quiet in these networks, and I message them privately, at times you find that a learner is struggling, and this private engagement helps him to explain what the challenges may be*", said Participant F. "*Because the number* *of learners who do Mathematics is very small, this platform allows me to reach all of them individually daily and this has improved their performance,*" outlined Participant J.

Another common finding among all participants was that remote learning offers learners adaptability not usually possible in the class setting. Rather than having all learners participate at the same time, teachers can plan separate learning time frames or individual lessons, give customized content, and consistently keep in contact for extra support. "*Learners are more at ease to communicate with teachers remotely without any fear of intimidation by their peers,"* indicated Participant H. "*This has increased participation by even shy learners,*" added Participant C.

Online learning permits learners to move from static learning materials to more dynamic engaging and interactive media content, according to Participant A, D and H. *"Learning has become practical, interactive and exciting for these learners*", comments Participant C. Another advantage of learning with ICTs as reiterated by Participants A, C and E is that learners frequently learn quicker when they are not just tuning into the educator and understanding course readings, in addition to taking an interest in connecting with networking platforms.

"*With the easy availability of information on the web, the teacher's function as a subject master turns out to be less basic. It is the capacity to manage learners through these volumes of data that truly matters in current schooling,*" indicated Participant G. This view was further shared by Participants D and F who both agreed that the role of the learner in the learning process has improved. Learning is mostly learner centred with minimal teacher's assistance. A similar view was shared by Participant J who indicated that, "*the tempo of the learning is basically controlled by a learner*".

*"Simultaneously, finding the best methods of gaining from various sources along with learners makes teachers co-learners as opposed to the sole wellspring of information"* highlighted Participant A. "*This system allows learners to concentrate on creating new content,"* added Participant B*. "It may appear as though teachers do not have much say in the lesson, yet truth be told, these new methodologies create genuine trust between both learners and teachers,*" says Participant H.

### e) Classroom atmosphere in a connectivism and ICT classroom

Eight of the ten participants agreed that in the beginning, these networks were not as effective as learners used this platform for more social contact than studying. However, the school closure due to lockdown created a sense of need to learn through these platforms. "*I first set the boundaries through classroom rules on these platforms,*" indicated Participant A. "*We have a policy which guides the times, language and participation procedures in these platforms with my learners",* adds participant F. "*We ensure that we monitor these networks so that they perform what is intended of them, so that they become safe learning spaces,"* indicated Participant J.

Learners seemed to depend on using this platform to ask for clarity and share solutions. Various schools formalized these networks, and their relevance and importance were recognized. *"We have included the use of cell phones into the classroom as part of our policy; something which was previously never allowed. The advantage is that it makes research easier, and they are linked with the school digital white boards which use Bluetooth to link the phones to take notes",* said Participant C. "*This saves time for note taking and some discussions are instant, and solutions are found on time,*" noted Participant H. "*The informality of this network makes a relaxed environment to allow learners to participate*", explained Participant F.

Participants further agreed that these networks are less intimidating than a traditional classroom where shy learners are unable to express themselves. "*These networks allow all learners to participate, share information and obtain clarity,"* noted Participant C. "*Even learners who are usually shy to participate in class, are a bit more comfortable to either ask a question or give input in these platforms,"* said Participant B.

All participants highlighted that teaching and learning have become easy in the remote classroom because much research is being done through networks and classes act as platforms to share ideas or findings. "*Learners are active participants unlike most of our class lessons where they become passive,*" said Participant G. "*When you give learners a concept to research to probe prior knowledge, they come up with brilliant inventions from the internet,"* agreed Participant A. This is in line with the advocates of connectivism that knowledge does not only reside with individuals but can be found in non-human appliances (Siemens, 2005; Downes, 2006).

All participants indicated that introducing topics in a normal classroom has become easy as learners would already have done their prior research, making a flow of discussion much easier. "*The virtual learning has also changed the atmosphere in the traditional classroom whereby learners come into class already prepared for what is to be discussed,*" acknowledged Participant G.

If used correctly, as indicated by Participants A, B, C and E, ICT instructional technologies in schools can possibly improve the learner's academic achievement. The participants further shared a common view that learning with ICT instructional technologies is learner driven and henceforth achieves dynamic inclusion of learners in the learning cycle. "*Learners get inspired when learning exercises are testing, real, multi-sensorial and multi-disciplinary,"* noted Participant E. Participants have generally indicated a higher participation, high motivation levels, improved academic achievements and collaborations as a result of the technological networks that they use as support forums. Teachers also gain because of technologically supported activities and networks such as PLCs. Participants further agreed that ICT instructional technologies are just as valuable for educating as for individual and expert work. Utilization of ICT instructional technologies in instructing makes learning more creative, intriguing, intuitive, simple and successful, highlighted Participant A. "*It supplements the conventional teaching and learning methods",* added Participant G.

**f) The effectiveness of ICTs in homework**

One of the most important factors which connectivism and ICTs bring into the learning sphere, is homework assistance. All participants had earlier indicated that ICTs and connectivism have enhanced a continuous learning beyond the classroom and they mostly use it for homework purposes. This review will therefore examine the participants' views on the effectiveness of using ICTs to give learners homework.

Participants G and F indicated that homework has become very effective and a central part of the lessons, as learners are able to research in the comfort of their homes, share with peers and find possible solutions for any given work. Participant G and F's views were further reiterated by Participant J who said that, "*What we do is called continuous classroom which extends to home, it is no longer the traditional homework",* and Participant A added that, "*these platforms have enabled learners to engage me even after school hours and there is a significant improvement in the completion of assignments*". Participant B further outlined that "*I have given learners an opportunity to contact me to seek clarity for any concept which may not have been clear in the classroom until 8 pm*". All the participants indicated that giving homework and allowing these learners to engage with their networks, has worked to reinforce concepts they have not understood in class. "*Some of these learners use these* *platforms to seek clarity from their peers, an opportunity a classroom does not offer,*" reiterated Participant F.

Participants A and D highlighted that when given work to complete at home, ICT instructional technology encourage flow of knowledge and all participants claimed that information development is rapid, and learners develop a variety of solutions. They further indicate that progressed learners require much time and practise, so homework allows these learners to learn in their comfortable surroundings at their preferred pace. All participants further outlined that there is multiple help at their disposal, other than in the classrooms where their source of information is an educator who may also be struggling in delivering such content.

**g) Challenges of teaching progressed learners using ICTs**

**i) Lack of resources, connectivity or gadgets**

As indicated earlier, of the ten participants selected, only two come from schools that have unlimited Wi-fi connectivity and learners are given tablets, while eight do not. This therefore determined the trends and frequency of participation. "*Due to the lack of ICT equipment or connectivity especially while at home, some learners delay connecting or do not connect at all to the networks hence they miss out on the discussions,"* said Participant D. "*This at times places them at a disadvantage of missing important information which may be useful the following day at school*", added Participant B. Participant B's notion was widely shared by the majority of participants.

Participant F further indicated that some learners are not a part of networks, and do not have smart phones, while some do not have access to data hence they can only access these platforms while they are at school. "*Our school is a Quintile 3 school dependent solely on government grants, ICT resources are minimal and not always available looking at the number of learners we have and have to share the computer lab with other subjects such as CAT and IT,"* noted Participant B.

**ii) Compact annual teaching plans**

One of the biggest challenges cited by all participants was the heavy workload of the annual teaching plan for the Grade 12 learners. "*We need to race to finish the syllabus while we need extra time to support progressed learners,"* indicated Participant D. All ten participants indicated that syllabi completion has been cited as one of the main challenges as there is so much to cover before the examinations begin, and Term 3 is basically used to revise as most exams begin early in Term 4.

This puts tremendous pressure on the progressed learners, as they need to catch up while learning new content daily. *"Because the workload is heavy for these learners, content is not fully explored due to time constraints,"* indicated Participant F. *"ICTs' full potential is not explored because we are pushing to complete the syllabus before the final exams,"* added Participant C. "*The teaching plans do not have a specific guideline on how to incorporate ICTs; it is up to each teacher as to how or when to use ICTs,*" noted Participant B.

**iii) Absenteeism**

There were conflicting views on the issue of learner absenteeism. Of the ten interviewed three participants (B, E and J) indicated that some learners prefer to learn remotely especially during the Covid-19 pandemic, and this has reduced school attendance by some learners. Participant A and C refuted this view, indicating that for them, there is high interest, and the attendance has improved. Participant F, who is a deputy principal, brought in a different view: "*My observation is it encourages educator absenteeism as they know they will be able to connect with their learners wherever they are.*"

"*The absence of learners places them at a disadvantage because certain discussions are still being carried on at school and teachers still like to continue with face-to-face teaching to correct some of the misconception learners may come across from digital platforms,*" said Participant A. "*Furthermore, formal assessments are still only carried out through face-to-face classroom learning not through connectivism networks hence these learners miss such",* added Participant B.

**iv) Lack of interest**

All the participants indicated that not all learners are part of these social networks due to lack of ICTs or connectivity, while others do not have any interest in the online learning platforms. Participant A indicated that she asked three learners who were not a part of any study group why they chose not to be, and they all indicated that they do not have any interest in this. On the one hand Participant D outlined that his learners' lack interest in participating is due to security issues that go with social media and fear of cyber bullying. "*These learners are placed at a disadvantage as they miss a lot of important discussions and shared ideas,"* added Participant E.

**v) Monitoring**

All the participants shared a common view that these platforms require constant monitoring and supervision by an educator. Participant C indicated that some websites offer information which may not be acceptable. It is therefore a teacher's responsibility to check every piece of information shared, and failure to do so may result in incorrect content being shared and correcting such misconceptions may be a tedious or futile exercise. Participant F raised a critical view that, "*some of these networks are not linked to the school hence their monitoring is not possible*". This, as indicated by Participant B, leads to learners using sites which may not be approved, or which provide wrong information. "*As much as these platforms offer learners freedom to learn on their own it is still a teacher's responsibility to align their findings to the content taught",* explained Participant E. "*The fact that these discussions occur mostly remotely, there are learners who simply become obstructive, post unnecessary jokes and it is up to me to call out such a learner"*, said Participant J.

#### vi) Educator participation and skills

One of the common issues raised by participants was that these groups are formed informally by learners and that teachers joined most of the existing groups. "*As an older teacher sometimes, these new technologies are a bit difficult to work with*", said Participant G. This was reiterated by Participant J by indicating that "*we need extra IT support from the Department to create working links using this digital technology*". Participant E said to improve some of his digital lessons they receive assistance from an external provider servicing the school and he is unable to upload and create certain Mathematical content. The common notion shared by all participants is the need for further training to align instructional technology into teaching to support low ability learners.

### 4.3.3 THEME 3: IMPACT OF SUPPORT STRATEGIES ON LEARNER PERFORMANCE

#### a) Tracking of progressed learners' performance

The following is a results analysis of progressed learners from three schools. Not all schools had tracking records of their progressed learners. Only three schools out of the ten were able to produce a tracking tool for progressed learners' Mathematics performance. Table 4.2 below is a tracking tool used in school A, B and C used to monitor their learners' progress from Term 4 of 2019 to Term 3 of 2020.

**Table 4.2 Three secondary schools Mathematics results analysis for progressed learners tracking tool**

| School A | | | | | School B | | | | School C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Term 4 2019** | **Term 1 2020** | **Term 2 2020** | **Term 3 2020** | **Term 4 2019** | **Term 1 2020** | **Term 2 2020** | **Term 3 2020** | **Term 4 2019** | **Term 1 2020** | **Term 2 2020** | **Term 3 2020** |
| **L1** | 17.00 | 26 | 39 | 70.00 | 14.87 | 28.00 | 34.00 | 68.00 | 38.00 | 42.00 | 46.00 | 58.00 |
| **L2** | 22.00 | 49.25 | 56.00 | 60.00 | 11.87 | 19.00 | 6.00 | 2.00 | 16.09 | 28.50 | 32.00 | 72.00 |
| **L3** | 41.9 | 27.05 | 44 | 64.00 | 23.65 | 30.50 | 8.00 | 2.00 | 10.65 | 32.25 | 34.3 | 54.00 |
| **L4** | 11.00 | 36.50 | 16.00 | 30.00 | 23.00 | 34.00 | 36.00 | 76.00 | 28.04 | 41.00 | 60.00 | 98.00 |
| **L5** | 10.43 | 25.25 | 16.00 | 2.00 | 17.03 | 34.00 | 36.00 | 58.00 | 12.87 | 25.75 | 31.1 | 2.00 |
| **L6** | 34.08 | 42.75 | 52.00 | 50.00 | 14.09 | 29.00 | 10.00 | 58.00 | 14.23 | 35.50 | 12.00 | 48.00 |
| **L7** | 29.00 | 48.50 | 40.00 | 42.00 | 21.00 | 61.50 | 48.00 | 56.00 | 30.00 | 46.75 | 47.2 | 80.00 |
| **L8** | 9.07 | 11.00 | 6.00 | 22.00 | 26.08 | 29.25 | 32.4 | 40.00 | 32.09 | 39.50 | 48.00 | 74.00 |
| | | | | | | | | | 11.07 | 25.25 | 31.4 | 2.00 |

According to Table 4.2 above, one of the first impacts of teaching with ICT instructional technology in a connectivism environment is an improvement in learner performance. These learners were progressed from Grade 11 to Grade 12. They failed Mathematics in Grade 11 and they were progressed to Grade 12 in 2020, and this table shows their quarterly performance from Term 4 in 2019 to Term 3 in 2020.

From the above analysis, as illustrated in Table 4.2, of the 25 learners in three different schools their four terms' marks were sampled and used as a tracking model to measure their performance through the four terms. Their results from Term 4 Grade 11 2019 to Term 3 2020, while they were in Grade 12 have been used to track their performance as they prepare to sit for their final Term 4 Matric examination. From the above table, only five learners had obtained a level 3, which is a 30% pass, by the end of Term 4 in 2019 in Grade 11 in the three schools analysed. In Term 1 of 2020 only 11 learners did not achieve a minimum requirement of 30%. There is a slight improvement in Term 2 as only 9 learners failed.

A major improvement becomes significant in Term 3 where, of the 25 learners, only 6 learners did not obtain the minimum required mark. One can draw the conclusion that there is a steady progress in learner attainment from Term 4 of 2019 to Term 3 of 2020. Learners who had failed Mathematics and were condoned to Grade 12 due to Mathematics failure, seem to be making steady progress in terms of performance. The Term 3 results indicated that of the 30 learners in this group, only eight were still not progressing.

According to all participants, even with those not being tracked, there is a significant improvement in the learners' Mathematics performance with extra support offered both at school and at home. This gives learners a chance to perform well in their Matric examination. All participants indicated that the support given has positively affected the Term 3 results although not all learners passed. The majority who would have failed Grade 11 due to failure in Mathematics, have displayed a great dedication and commitment towards support sessions, resulting in a better performance as illustrated in Figure 4.12 below.

Figure 4.12 below is an illustration of a downward trend in the failure rate of Mathematics of the progressed learners as indicated in Table 4.2 above.

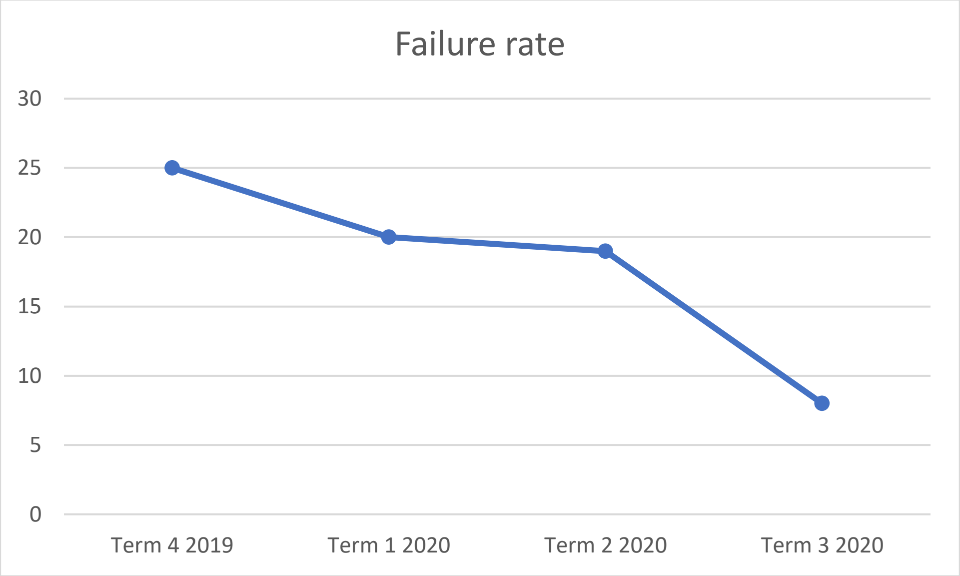


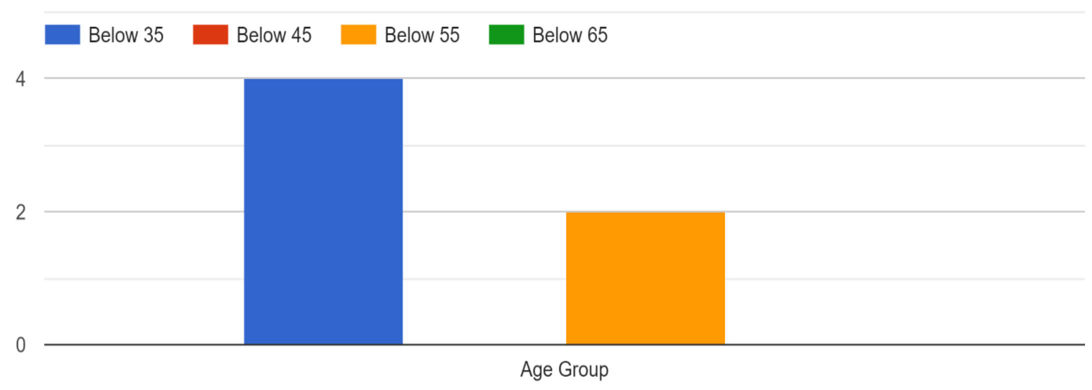

**Figure 4.12 Failure rate of progressed learners at school A, B and C**

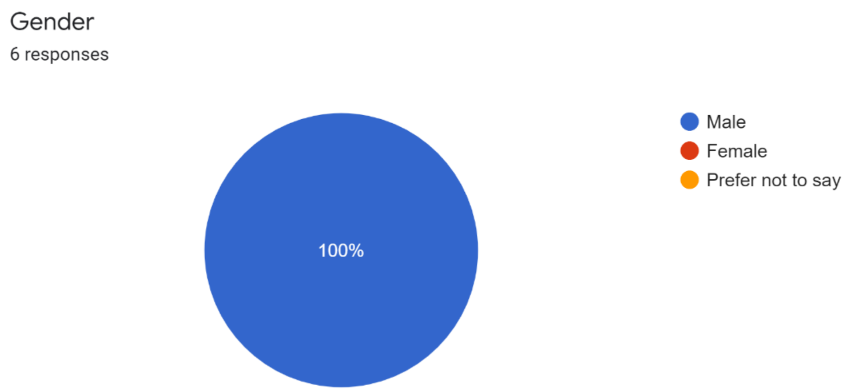
Figure 4.12 above indicates a downward trend in terms of the failure rate of progressed learners from the three abovementioned schools. In Term 4 2019, while these learners were in Grade 11, the failure rate was at 25 % of all the sampled classes in Mathematics only. In Term 1 of 2020, there was a slight decrease to 20% while Term 2 still indicated a downward trend although not as significant. In Term 3, there is a big decline of learners failing Mathematics; the failure rate was below 10%. All participants indicated that the support strategies that educators applied throughout the terms have produced positive results. "*These learners have a big chance of obtaining a Mathematics pass when school-based assessment is added to their final examination,*" noted Participant D.

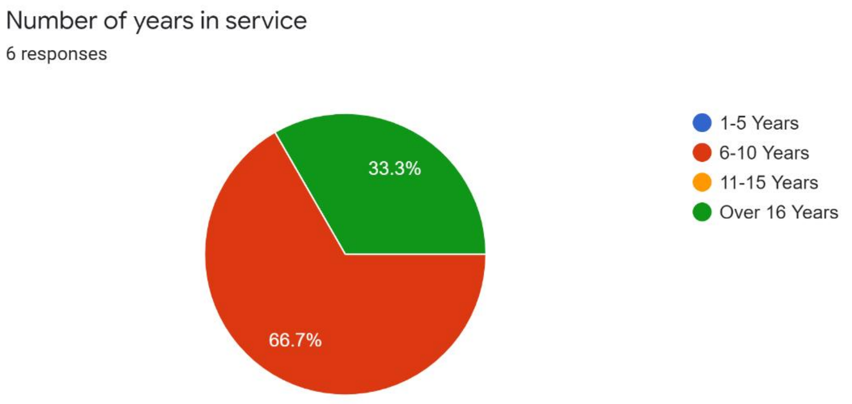
## 4.4 SECTION 2: QUESTIONNAIRE RESULTS ANALYSIS

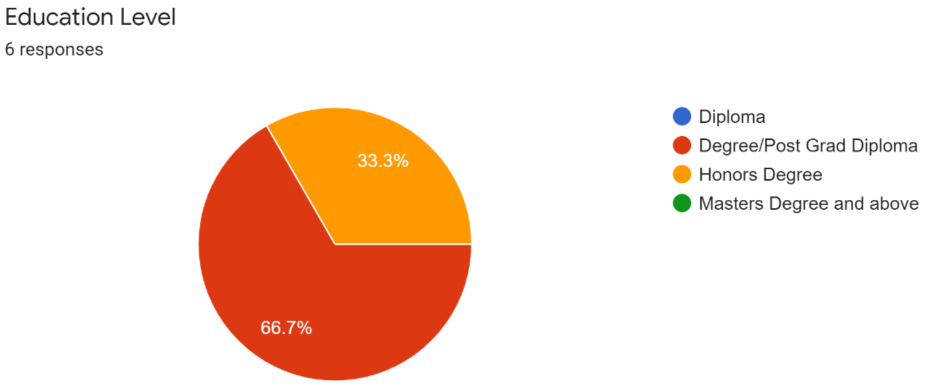
The following analysis was derived from a set of questions which were sent to participants who support progressed learners using alternative strategies to technology. Figure 4.13 below is a biographical representation of all participants who took part in the questionnaire.

SECTION A: DEMOGRAPHIC INFORMATION





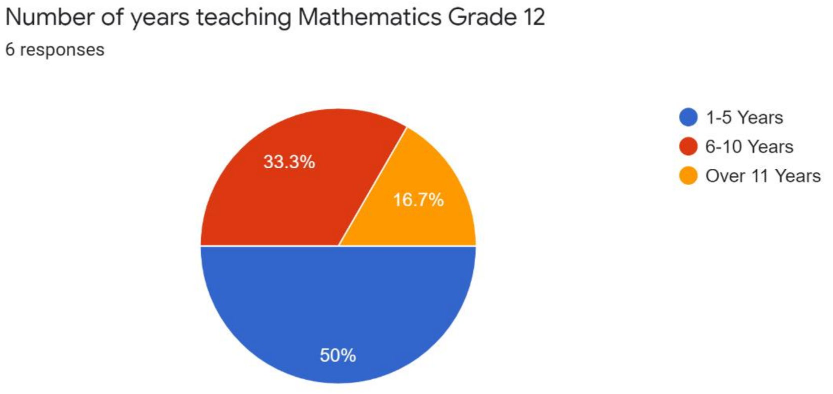




**Figure 4.13 Teachers' biographical information (Cohort B)**

## 4.4.1 SUPPORT STRATEGIES USED TO SUPPORT PROGRESSED LEARNERS

### a) Extra lessons for reinforcement and revision

All six participants shared one response to the question of the type of support strategies used to support progressed learners. They indicated that they offer extra lessons which are dedicated solely to low ability learners as a core way to address and reteach concepts which are challenging. What differed was the preferred time frames for these extra teaching sessions.

From the six participants the following Figure 4.13 indicates the most preferred time for extra lessons for progressed learners.

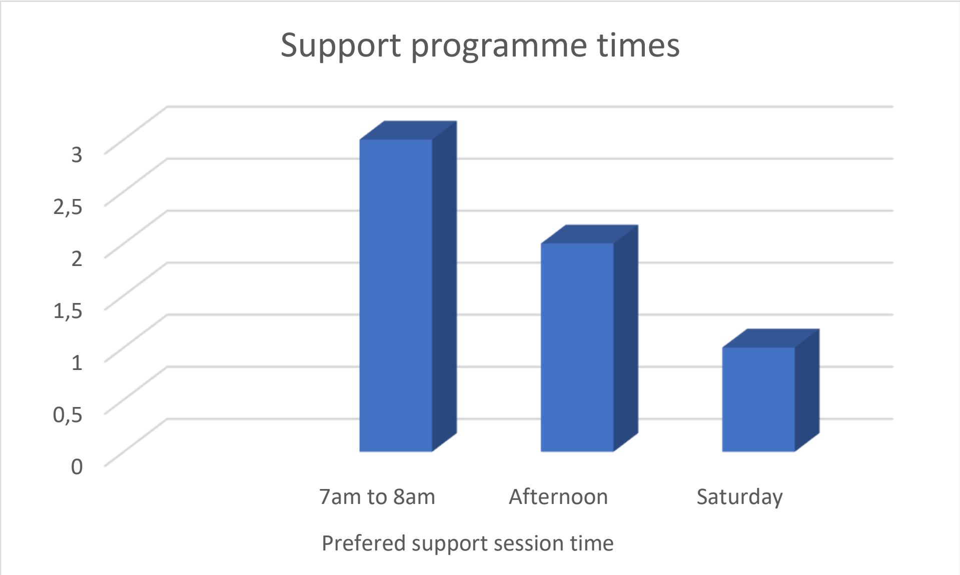



**Figure 4.14 Preferred support session time frames**

According to Figure 4.14 above, three of the six participants preferred to have extra lessons in the mornings, while two indicated to use afternoon classes and only one participant indicated Saturday extra classes as the most effective support strategy used to support these learners. These are face to face contact sessions where teachers use past question papers, memorandums and other resources to reteach challenging concepts.

*"We use morning, afternoon and night classes. We concentrate on individual learners' needs by focusing on a specific topic. The learners who receive low marks are given low order questions to train them in recalling information easier. It is not a priority to do high order questions but to get them through to pass mark",* indicated Participant 3.

*"Group them and have a special class only for them. Either have morning classes or afternoon classes where we focus on basic Mathematical skills*", said Participant 5.

**b) Content gaps and critical areas**

The second strategy as indicated by participants is to concentrate on level 1 and 2 questions and re-emphasis basic Mathematical skills. According to the participants level 1 and 2 questions are basic Mathematical skills which constitute up to 30% of the pass mark, this then means mastery of this part may ascertain a pass mark as per CAPS policy pass requirements. One common assertion was to give weekly practise tests and revise solutions using separate support or intervention books. These findings were common among all participants.

*"I emphasize on areas where learners are struggling",* said Participant 2.

*"We drill and practice past question papers and give them weekly tests that focus mainly on level and two questions",* notes Participant 4.

*"We do thorough analysis of results and group learner's according to their levels. The learners who receive low marks are given low order questions to train them in recalling information easier and we use previous question papers because they provide a standard to bench mark the low order questions",* noted Participant 6.

**c) SSIP Classes**

SSIP is a School Support Intervention Programme which is funded by the Gauteng Department of Education which offers learners an opportunity to attend Saturday support sessions and different tutors, or educators are appointed to facilitate the teaching and learning. The participants have indicated to be a part of this programme and use this opportunity to address challenging concepts oin a face-to-face lesson, and have ample time to address different groups of learners according to their academic needs. They are also a part of PLC groups; these are professional learning communities among Circuit 4 cluster teachers for each subject area, where they share best practices and support strategies, resources and materials which can enhance teaching and learning. The schools are grouped in a circuit geographically within a district. The participants indicated that they are part of PLCs and also teach in SSIP classes where grade 12 learners are clustered into for extra support lessons.

### 4.4.2 THE SIGNIFICANCE OF THE SUPPORT STRATEGIES USED BY THE PARTICIPANTS

According to all participants, extra lessons or classes which are more focused on progressed learners assist learners to grasp concepts better than in a normal classroom setting where learners are mixed, and the pace may be quicker. Secondly, all participants shared a common view that giving these learners individualized support, enables them to understand concepts better and they communicate better in smaller groups than in a bigger classroom with other learners. Another commonly shared view was that concentrating on low order questions enables learners to at least attain a 30% pass mark which is a minimum requirement to pass Mathematics.

### 4.4.3 THE BENEFITS OF THE APPLIED SUPPORT STRATEGIES

The following list indicates common views of observable benefits of supporting progressed learners as reiterated by the six selected participants:

- Learner performance improves (at least 30%)
- Learners are exposed to the questioning styles through drilling of past question papers
- Concepts addressed in a smaller group are better understood
- It enhances learner technique of handling questions
- It reinforces Mathematics basic skills.

### 4.4.4 CHALLENGES OF SUPPORTING PROGRESSED LEARNERS

As much as educators indicated that there are benefits of supporting progressed learners, they have however indicated that there are also challenges experienced in their intervention processes. The following list is their common responses of the challenges they experience in supporting these learners:

- Poor participation or attendance of extra lessons
- Lack of commitment by some learners
- Lack of parental support or involvement
- Late coming to some of the extra lessons
- Lack of resources in the schools.

### 4.4.5 EXTERNAL SUPPORT OFFERED TO PARTICIPANTS BY SMT AND DEPARTMENT OF EDUCATION

All the participants indicated a need for school management to engage the parents of learners who are progressed, and obtain their support with the programmes so that they can monitor their learner's attendance. They have further reiterated that the school must ensure that these programmes are financially supported to enhance ease of participation. This could be through offering these learners food in the afternoon, offering them extra resources such as copiers and printers for worksheets and make classes available in the afternoons or on Saturdays, as some schools are locked after hours for security purposes. The participants have also indicated a need to be assisted with monitoring of attendance by management to ensure that learners regard these lessons as important as attending a normal lesson.

As do the senior management, the participants indicated that there is a dire need for progression or support lessons to be supported by the Department of Education. As indicated by Mr Lesufi, Gauteng Education Department MEC, cited by Zimasa (2016), the Department will commit resources to ensure that progressed learners in Gauteng province receive the necessary support required to enhance their performance. This declaration, which was made in 2015, saw the birth of SSIP classes which are Saturday extra lessons and teachers who teach these learners are reimbursed. All the participants indicated that they are part of the SSIP teachers and are fully involved in teaching during Saturday sessions organized by the Department.

There are also camps during school breaks organized by the Department of Education in Gauteng. All participants indicated that they participate in these camps as well, but these camps cover all Matric learners, not only progressed learners in preparation for their final Matric examinations. Participants 5 and 6 however indicated that there is little to minimal impact that these camps have towards progressed learners as they are normally bigger groups and are not structured properly.

Participants further indicated that the Department monitors learner's attendance to SSIP and camp classes and they support them with worksheets. Over and above the extra lessons offered, participants indicated a need for resources such as connectivity for easy research by the Department.

### 4.4.6 THE TEACHERS VIEW ON PROGRESSION POLICY

As indicated by Zimasa (2016) in a study conducted among the South African teachers, progression policy affects learners' pass rate. This study's participants echoed the same sentiments. All the six participants reiterated that the progression policy must be reviewed and the requirement for progression must be amended. Two participants indicated that the learners' school attendance and commitment must be considered in order for a learner to be progressed, as the support process requires a high level of commitment. Two participants outlined that those learners must be progressed on merit and only learners who are willing to work hard should be progressed.

### 4.4.7 PROGRESSED LEARNERS' RESULTS ANALYSIS AND PERFORMANCE TRACKING

Figure 4.15 below indicates the progressed learner's performance for Term 1-3 and the preliminary exam. According to this figure, it is noted that there is not much progress achieved especially at the end of the year with preliminary exams as they paint a picture of what the final examination performance will look line. The figure indicates that during the end of year preliminary examination, no learner attained above 50% who was progressed, and the majority of learners scored below 30% and this fact is also reflected in the literature review.

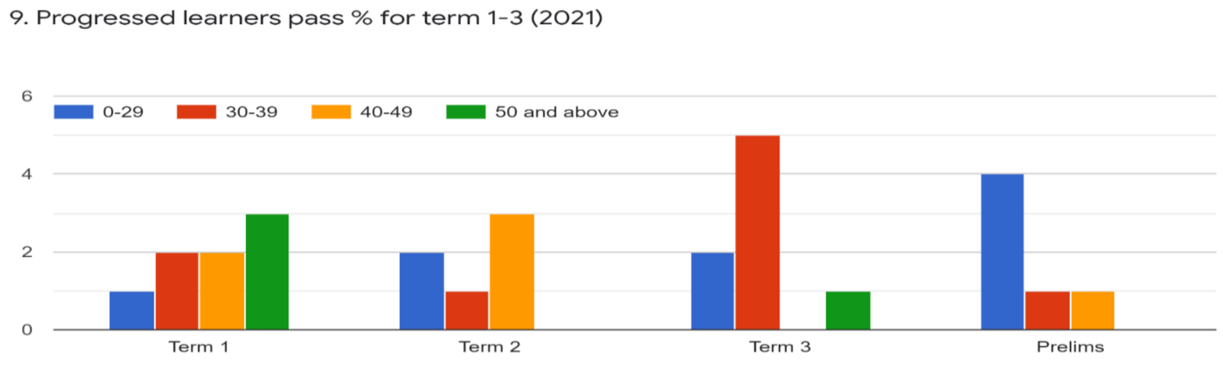



**Figure 4.15: Progressed learners' performance for Term 1-3 (2021) and preliminary exam**

Looking at the results above, participants indicated that progressed learners decrease or lower their overall learner pass rate and contribute negatively to their general performance. Participant 5 notes that "*majority is dropping the average and the percentage with only one or two who end up passing at the end of the year*", and this view is further supported by Participant 6 by indicating that *"they are not used to going an extra mile for their grade, hence they fail".*

In conclusion, this section has given a description of support strategies used by teachers which are not embedded in technology. One then concludes from the participants that there is a need for aligned structured ways to support progressed learners, a need for resource provision and policy review in order to improve their performance. The following section is a comparative description of supporting progressed learners using ICT instructional technologies to using other alternative strategies as cited by participants in cohort A and B.

### 4.4.8 COMPARATIVE ANALYSIS OF FINDINGS

#### a) Support strategies used

There is a serious need to improve the understanding of learners' learning ability, the way they reason and their prior background in order to make Mathematics teaching and learning a success. It therefore calls for teachers to re-draw their teaching and support strategies which will have a needed impact especially on progressed learners.

All sixteen participants agreed that there is a knowledge gap and poor knowledge of general Mathematics basics which constitute at least a 30% pass mark. The general argument from the participants is that concentrating on filling this gap will contribute positively into the Mathematical attainment but what differed were strategies employed by these two groups of teachers (Cohort A and B). Educators who were interviewed advocated for the use of digital networks to disseminate information while the teachers who participated in the questionnaire believed face-to-face in smaller group classroom engagements are their way of filling the content gap.

All teachers from both cohorts believe that Mathematics learning is a continuing process which extends beyond the traditional classroom in which learners grow a deeper comprehension of correct Mathematical concepts and processes. This common agreement saw the use of extra classes, as reiterated by six teachers, and digital online networks as argued by ten interviewed teachers as some of the strategies which could be developed to enhance and improve the process of learning Mathematics.

The support strategies employed by these two cohorts (A & B) are influenced to a large extent by the behaviorist, constructivist and connectivist theories. The six participants who participated in the questionnaire believed in reinforcement of concepts through drill and practise which is a behaviorist school of thought (Reimann, 2018) as compared to the ten educators who were interviewed who strongly believed in knowledge creation and discovery learning (constructivism as explained by Mattar, 2018) and collaborative learning through digital networks (connectivism) as outlined by Siemens (2006).

As indicated by the six participants in Cohort B the teaching approach places more attention on the teacher as a knowledge source which represents a behaviorist approach while the ten interviewed participants believed in peer education, which is a learner centered approach which believes in knowledge sourced from human and non-human sources (which is a more constructivist connectivist approach). In the constructivist view (Anderson, 2018) in Mathematics learning, learners must create their individual comprehension of Mathematics concepts, so the goal of teaching does not rely on passing through Mathematical knowledge creation. What the Cohort A teachers do is they have brought in connectivism school of thought to complement constructivism type of learning through online remote learning using various networks and knowledge sources. The interviewed educators in Cohort A believe in diverse information and giving information and giving attention to the learning process while teachers in Cohort B place more attention in attaining a minimal 30% pass rate.

**b) The impact of support strategies used**

Looking at both results as outlined in Table 4.2 and Figure 4.15, from both Cohort A and B, one can describe that Cohort A (who use both the traditional classroom and digital technological instructions) have observed a positive impact compared to the Cohort B teachers who experienced a decline in learners' performance.

One then notes that Cohort A teachers' strategies of the application of multiple teaching strategies does become one of the critical tools which could be used as intervention strategies to support progressed learners. The idea of individualised support strategies offered by Cohort B educators is similar to the small support networks in Cohort A, but what gives these learners an advantage is the availability of resources through different networks, the pause rewind features which are similar to drill and practise, and the comparative type of learning offered by networks and connections.

The Cohort A teachers reiterated the use of concrete and digital manipulatives as teaching aids. This is in contrast with Cohort B teachers who preferred worksheets, past question papers and exemplars. The benefits of teaching Mathematics from concrete to abstract has been noted as learning becomes practical (Kumar & Kumara, 2018) it allows for a differentiated Mathematics approach (Valiande & Tamara, 2011) and learning through discovery enhances practical basic Mathematical skills (Yadav et al, 2018).

**c) Challenges of support strategies**

Looking at the level of participation, both teachers in Cohort A and B share a common view that not all learners under intervention programmes do actually participate. Poor attendance, lack of commitment or interest, lack of resources (coming to camps or Saturday lesson or internet connectivity) were mentioned as barriers to the successful participation into the intervention programmes.

What differed between the participants was the flexibility offered by networks that a learner can find information in his or her own time and may be able to catch up, unlike the face-to-face support sessions where a learner may not be able to understand if he or she had missed a lesson.

## 4.5 SECTION 3: DOCUMENT ANALYSIS

### 4.5.1 INTRODUCTION

This sub-section investigated the policies that guided the progression policy in the South African schooling system. More focus is based on the movement in the FET phase. The second part of this section reviews a sampled lesson plan and describes how teachers integrate ICTs into their teaching and learning.

As indicated in the methodology, part of the data came from the analysis of documents that support the progression policy. These are policies that guided the schools on the procedures to follow in progressing learners and supporting these progressed learners.

**a) Policy review**

The following policies give a guideline on how learners should be moved from one grade to the next. As earlier indicated, the South African School Act gives a directive in terms of the number of years in the phase and the age cohort of a learner in order to be correctly placed in a grade. According to the SASA no learner should repeat a grade twice or be in a phase over a period of four years, these learners should be progressed to the next grade regardless of his or her results (DBE, 1996). The progression requirement, which prohibits grade repeating and restricts it to once within each of the four phases of basic education, was first implemented in the Further Education and Training (FET) phase in 2013. The first cohort of progressed learners did Grade 12 in 2014.

The National Policy Pertaining to the Promotion Requirements of the National Curriculum Requirements for Grade10-12 (2016), as depicted from notice No R1114 in regulation Gazette No 9886 of December 2012, outlines a detailed criterion for moving learners in Grade R to 12. As outlined in this policy, a learner can only repeat once in this phase so as not to spend more than four years in the phase. This policy specifies that if a learner has to repeat a grade for the second time, he or she must be moved to the next grade and schools have been instructed to offer such learners extra support in the grade. According to DBE (2017), the rationale behind the policy on progression is to reduce the possibility of high dropout rates and increase school retention. This system is not new, it is regarded as an international best practice in countries such as Finland, Sweden, Denmark, Japan, Korea and the United Kingdom (DBE, 2017). The idea is that, rather than forcing these learners to continuously repeat a grade, give them a chance to proceed to the next grade and offer them extra assistance and support. For a learner to be progressed to the next grade within the

FET phase there is a stated criterion which educators have to follow. The following is an analysis of the FET phase progression guidelines beyond what was prescribed in the NPPR.

Circular E 35 of 2015 and Circular E 22 of 2016 (DBE, 2015 & DBE, 2016):
These criteria were set to ensure that such learners meet certain basic requirements to cope in the next grade.

- The learner, according to the two circulars, must have failed and repeated at least Grade 10 or 11 in the FET phase.
- To progress, the learner must have passed the school language of teaching and learning in at least three of the seven subjects offered.
- His or her school attendance must also be on a regular basis; if a learner is absent for more than 20 days without a valid reason, such a learner may not be considered for progression.
- For a learner to further qualify for progression, he or she must have complied with school-based assessment requirements.

The above criteria do not specify which subjects a learner must pass other than the language of teaching and learning. This then indicates that the passing or failing of Mathematics in FET phase is no longer a pre-requisite or a determining factor towards a learner's promotion to the next grade. This is in line with the lower grade circulars such as circular 1 of 2020 which advocated the condonement of Mathematics.

The two circulars further state that progressed Grade 12 learners may choose the multiple examination opportunity option. This indicates that they may decide not to write all six subjects in the November exams. They may sit for the remaining subjects the following June. The intention is to give the progressed learner an opportunity to prepare and concentrate on lesser subjects at a particular time. The learners are continuously monitored through Grade 12 to ascertain that they are coping. Their performance is monitored through school-based assessments and those who are struggling are assisted to apply for a multiple examination opportunity (MEO).

### b) The MEO policy

According to DBE (2020), the MEO policy ended at the end of 2019 academic year. This policy allowed learners to divide their examination into two. A learner could write at least three subjects, excluding Life orientation, in the November examination and the remaining subjects in the following June. What determined the MEO was the learner's preparatory examination marks. MEO gave learners a chance to focus on lesser subjects which they were confident to write at the time and were given an extended period to prepare for the remaining subjects within a period of extended six months.

This reduced pressure on these learners and offered them extra time to prepare for the remaining subjects. Only progressed learners in Grade 12 who met the earlier stated criteria were given an opportunity to modularize. As indicated in DBE (2020), MEO was stopped due to the high failure rate, or the failure to write the remaining subjects due to the lack of support. These learners had to prepare for the second sitting of their exam. These learners wrote the June papers while they were already out of formal schooling. They had to prepare for these exams privately with minimal support from educators. This then brought into play the concept of remote learning. These learners are no longer expected to enrol in the face-to-face classes; they are supported through private networks which they have created. This promoted the idea of connectivism as a better learning strategy for these learners to ensure that they are ready for examinations.

#### c) Grade 12 Mathematical lesson plans

A lesson plan is a daily or weekly plan that indicates the concept an educator will be dealing with and how it will be dealt with. It indicates the type of content and what activities will be done by both the teacher and the learners. In a connectivism classroom, learners choose how they learn. It enhances group collaboration, class discussions, changing of varying ideas, views and perspectives to reach a decision, solve problems or comprehend certain information. The following lesson plan was taken from one of the participating schools and it illustrates how connectivism is linked into the classroom.

Below in Table 5.1 is a weekly extract of an educator’s lesson structure from Participant A’s school. Its purpose is to illustrate how ICT is infused into a Mathematics lesson to support progressed learners.

**Table 4.3: Grade 12 Mathematics lesson plan: School A given by Participant A**

| | | | | |
|---|---|---|---|---|
| **Grade 12** | **Subject: Mathematics**<br>**Time 60 min** | **Term 1 Week 1** | **Topic: Arithmetic sequence and series** | **Lesson 1** |

| | | | |
|---|---|---|---|
| **LESSON SUMMARY FOR: DATE STARTED:** | | **DATE COMPLETED:** | |

| | |
|---|---|
| **LESSON OBJECTIVES** | **The following concepts will be revised:** Number patterns of the format $T_n$ □ $an$ □ $b$ from Grade 10. Number patterns of the format $T_n$ □ $an^2$ □ $bn$ □ $c$ from Grade 11. |

| TEACHER ACTIVITIES | LEARNER ACTIVITIES | TIMING | RESOURCES NEEDED |
|---|---|---|---|
| **vii) Teaching methods:**<br>Group Discussions, Presentations, Explanation, questions and answers.<br>**viii) Lesson development**<br>**a. Introduction**<br>Pre-knowledge required for this lesson: Number patterns<br>This is the first lesson thus there is no base line assessment<br>**b. Main Body (Lesson presentation)**<br>Revise the Grade 10 work on the format $T_n$ □ $an$ □ $b$. The following type of examples could be used:<br>The general term $T_n$ of a sequence is given by $T_n$ □ $6n$ □ 2. Find the first four terms of the sequence.<br>$T_1$ □ 6(1) □ 2 □ 8<br>$T_2$ □ 6(2) □ 2 □ 14<br>$T_3$ □ 6(3) □ 2 □ 20<br>$T_4$ □ 6(4) □ 2 □ 26<br>□ sequence is 18;14;20;26;. | Informal Activity Learners are asked to break into groups of 5<br>First learner to research on number patterns<br>Second learner to create a slide presentation on number patterns<br>Third learner does a slide presentation on number patterns<br>Another learner presents online findings on various methods used<br>Another learner will use a differing blogging platforms to show another method used<br>Another learner will consolidate all into a video presenatation for the rest of the class | Baseline:<br>0 min.<br>25 min.<br>Group presenta-tion: including the class work 35 min. | ix) Classroom Mathematics Grade 12 Learners Book Chapter 1 pages 1– 36<br>Laptops, Cell phones, projectors<br>x) Classroom Mathematics Grade 12 Teacher's Guide Chapter 1<br>xi) Via Afrika Mathematics Grade 12 Learners book Term 1 Chapter 1<br>4. Via Afrika Grade 12 Teachers Guide Term 1 Chapter 1 |

The lesson plan above shows a connectivism lesson plan cited from Participant A. The teacher divided her class into groups of five. The topic was to research on Arithmetic sequence and series. Each learner was tasked with a role to either research or make a presentation. They could consult other networks such as their classmates, using WhatsApp or Facebook to gather information or for further research.

The ultimate product was a class presentation on the lesson. In a connectivism classroom, learners choose how they learn. From this class, group collaboration is enhanced, class discussions are functional and there is an exchange of varying ideas. Teaching and learning is learner centred and learners choose how to learn while the educator facilitates the learning process. From the learner's activity column, there is a maximum participation of all the learners in different roles within this lesson, and application of networks and ICTs are evident.

Participant F indicated that the departmental lesson plans do not dictate the type of teaching methods or support strategies one must apply. He then improvises with the resources on hand to accommodate low ability learners. This participant indicated that he uses YouTube to introduce most of his lessons, or visual tutorials that are captivating. He then instructs learners to decode meanings from their observations and his role is only to guide the discussions.

Teacher F uses Microsoft Word to draw lines of 2D and 3D shapes and video links to introduce the concept of angles. The objective of this lesson is to introduce the concept of angles, but learners need to understand the way shapes are built and how angles are measured. He introduces the lesson by showing a video clip of a demonstration of building a 2D shape. He further uses colour and sound for emphasis. *"Learners are able to download this link at home in their own particular time, follow the instruction and make sense of the concept*", indicated Participant F. They are further given a platform to engage with either the teacher or other learners within their link, should they not understand a concept.

This strategy was also shared by Participant E, who also uses YouTube videos for demonstrations especially for complex topics. She indicated that she sends the link home via either WhatsApp or Telegram and instructs learners to watch it in preparation for the following day's lessons. She says this strategy has increased learner participation and interest and saves a lot of time that ultimately assists in syllabi completion. Participant C further added that, "*some practise material is found on Facebook with clear comments and notes and I advise the learners to join the group platforms that are accessible, namely Wiki educators, E-Learning in developing and developed countries, Teaching Critical Thinking and Active Learning".*

## 4.6 CONCLUSION

This chapter outlined a detailed presentation of the data that emerged from the semi-structured interviews, questionnaires and document reviews. The analysis was structured and presented through three sections and themes to address the research questions. The first section looked at how instructional technologies can be used to support progressed learners. Findings were presented using themes and the first theme investigated the type of ICT tools and networks created at the participants' schools. The second theme investigated the network's effectiveness in terms of usage and popularity and learner performance. It further described the benefits, the impact and the challenges of integrating ICT into teaching to support progressed learners. The third theme described the findings from tracking tools to analyse progressed learners' performance.  The second section investigated the alternative ways to support progressed learners without technological applications. The third section did a description of progression policies within the South African education system, and a comparative analysis of using ICT instructional technologies to support progressed learners and non-ICT instructional technologies.

This study was aimed at realising the following objectives; firstly, to describe how ICT and non-ICT strategies can be used to support progressed learners and their impact in Grade 12 Mathematics using connectivism theory. The analysis of this study outlined and described ICT instructional technology strategies which were used by participants in Cohort A to support progressed learners and non-ICT strategies used in Cohort B to support learners. Firstly, it was through the use of various digital social networks such as WhatsApp, Facebook, Telegram, Share It, Microsoft Teams, Zoom meetings and Google classrooms and the applications such as Geogebra, Jamboad and Desmos in order to teach Mathematics in concrete and practical ways. The second cohort indicated the use of extra lessons or contact time through morning classes, afternoon classes SSIP classes, PLCs and study camps. The study further outlined the popularity and the level of usage of these strategies as described by the participants. Findings then indicated that certain schools are more active than others and certain applications such as WhatsApp are mostly used in comparison to other networks.

The study then described the type of digital networks used to support progressed learners. These networks according to participants are between teachers (through their PLCs), among learners from the same school, among learners from two neighbouring schools and within the cluster. The networks are further accessed through digital platforms with a larger community of learners offered through networks such as Facebook, within communities by using the local libraries and study groups, and other digital platforms such as webpages and Education Departmental websites such as Thutong and siyavula.com.

Thirdly the study described how connectivism theory and ICT instructional technologies can be used to support progressed Mathematics learners. As established by participants, learners have created connections or networks among themselves where they share ideas and discuss Mathematical problems. Teachers also have their networks with fellow teachers (PLCs) and with fellow learners to share best practices. Work is sent to learners through digital platforms to enhance continuous learning beyond the classroom, drill and practise and practical concrete learning strategies for which the study has established yields positive results. Knowledge creation through the use of connectivism now lies in the hands of the learners. Peer learning and learners determine how they learn and there is accessibility of resources derived from various study connections accessed through ICT platforms.

The results of this study have moreover established the effectiveness of digital networks as support strategies teachers use. According to the participants in this study, these networks are effective, and these were established by the number of learners who participated in these networks, their improved Mathematics performance and the frequency of their participation in their networks.

The study went further to track the performance of progressed learners supported using connectivism as a strategy. Comparing both Cohort A and B learners, it can be concluded that Cohort A schools have established an upward trend in terms of learner performance through the three terms in comparison to Cohort B learners who are able to only attain a 30% pass mark. This attainment was established in the Cohort B respondents who reiterated that they only focus on 30% types of skill hence they attain such.

A comparative description of the non-ICT strategies and ICT strategies used to support progressed learners were given. It can then be established that Cohort A teachers are mostly aligned to connectivism school of thought in terms of their teaching while Cohort B teachers lean towards a behaviourist school of practice with their insistence of 30 % attainment and teaching pedagogies.

As one of its objectives, the study described the benefits and challenges in supporting progressed learners in Mathematics with ICT and non-ICT instructional strategies. There were similar findings in terms of challenges the teachers encountered, these being, the compact syllabus for Mathematics which needs to be completed before examinations while supporting progressed learners at the same time.  Lack of resources and time to support them, hence introducing extended contact time which Cohort A using ICT instructional technologies, while Cohort B supports with the use of extra morning, afternoon, evening, SSIP or evening lessons. Teaching a mixed class of both high and low ability learners, was also a major challenge and the learner's level of commitment was also indicated as another hindering factor for both teachers' cohorts.

Despite the above challenges, the study has established that it is indeed possible that progressed learners are able to attain better results if they are part of support programmes.

This has been established further through the literature review of the Matric performance over the years. The most significant benefit established through this study is improved performance of these learners as they progress through the year.

One can further draw the conclusion that although the annual teaching plan does not specify which support strategies need to be applied to support progressed learners, educators do make an extra effort with the limited resources to find a way to support these learners. They are able to incorporate connectivism and ICTs into their support strategies and there are visible benefits.

On further examination of the policies guiding progression, one can draw the conclusion that there is a legal framework guiding the implementation of progression, but there is no standard guide on how to support progressed learners. One finds that even in one school, two teachers teaching the same Grade 12s, use different support strategies. There is no uniformity or formal guideline that guides them on ways of supporting progressed learners. It rests upon an individual to devise some programme which can assist these learners.

As noted by Downes (2019), connectivism has improved learning ability by the learners, because they self-manage their learning patterns and styles. Learning has become learner-centred, learners share ideas and make their own findings using various resources. Teaching and learning do not only depend on an educator and there is a coherent link between the CAPS content and connectivism used with the ICT ideology.

To conclude, the results have established that ICT instructional technologies and non-ICT instructional technology strategies can be used within a connectivism theory as support strategies to improve the performance of progressed learners. The following chapter gives a detailed description of the study findings from both cohorts.

# CHAPTER 5: FINDINGS

## 5.1 INTRODUCTION

The study wanted to describe the support strategies for progressed Mathematics learners using ICT instructional technologies in connectivism theory and non-ICT strategies. The following chapter is a discussion of the findings derived from the data analysis. Three sets of data were presented in the previous chapter and the comparisons were drawn as well.

The importance of using ICT instructional technologies to enhance teaching and learning has been established from the reviewed literature in a connectivism classroom. Siemens (2005) and Downes (2006) have indicated the role of connectivism since the inception of ICTs and its introduction into the classroom. The literature findings suggest that the utilization of ICTs in teaching and learning is vital, efficient, captivating and alluring. With the innovative way in which it has been introduced in the teaching and learning setting, connectivism has proven to be the most efficient theory to support progressed learners in Mathematics (Gross, 2007). According to Meyer and Gent (2016), the relevance of ICTs is depicted as a support mechanism towards teaching and learning when used within a connectivism setting in facilitating teaching and learning.

Gross (2007) and Karma, et al. (2019) have indicated that several countries have created intervention and support strategies to improve Mathematics performance in the classroom, and one of the interventions introduced was the use of remote learning via the use of ICT instructional technologies. This remote learning enables learners to access materials not only from their teachers, but also from multiple sources and some non-human as argued by connectivist scholars such as Downes and Siemens. The findings show the role ICT instructional technologies play in supporting progressed learners using connectivism, the benefits and the challenges teachers have experienced, and these were further compared with other strategies which are not ICT related. A framework will be presented which encompasses what the researcher believed to be best practices from all sets of data consolidated together in a single tool.

The following are the set of questions this study aimed to answer:

**MAIN RESEARCH QUESTION**

How can ICT instructional technologies and connectivism theory be utilised to support progressed Mathematics learners?

**Sub questions**

- What ICT and digital network strategies can educators use to support progressed learners in Grade 12 Mathematics?
- What type of digital networks can assist in supporting progressed Mathematics learners?
- What is the effectiveness of the current support strategies on progressed Mathematics learner performance?
- What other strategies exist to support progressed Grade 12 Mathematics learners?
- What are the benefits of using ICT and non-ICT instructional technologies to support progressed learners?
- What are the challenges educators encounter in supporting progressed learners in Mathematics with ICTs and non-ICTs instructional technologies?
- How can connectivism theory and ICT instructional technologies be used to support progressed Mathematics learners?

The following objectives of this study were realised:

- to describe how ICT and non-ICT strategies can be used to support progressed learners and their impact on Grade 12 Mathematics using connectivism theory.
- to describe the type of digital networks used to support progressed learners.
- to assess the effectiveness of digital networks as support strategies teachers use.
- to describe how connectivism theory and ICT instructional technologies can be used to support progressed Mathematics learners.
- to track the performance of progressed learners supported using connectivism as a strategy.
- to describe the benefits and challenges in supporting progressed learners in Mathematics with ICT and non-ICT instructional strategies.
- compare the non-ICT strategies and ICT strategies used to support progressed learners
- design a framework to support progressed learners in Mathematics in Grade 12.

## 5.2 HOW CONNECTIVISM, ICT INSTRUCTIONAL TECHNOLOGIES AND NON-ICT CAN SUPPORT PROGRESSED LEARNERS IN MATHEMATICS

Figure 5.1 below gives a summary of digital and non-digital connections utilised to support progressed learners. The figure has integrated both the non-ICT connections which exists among these learning communities and ICT instructional technological networks which co-exist among the participants, their learners and their schools.

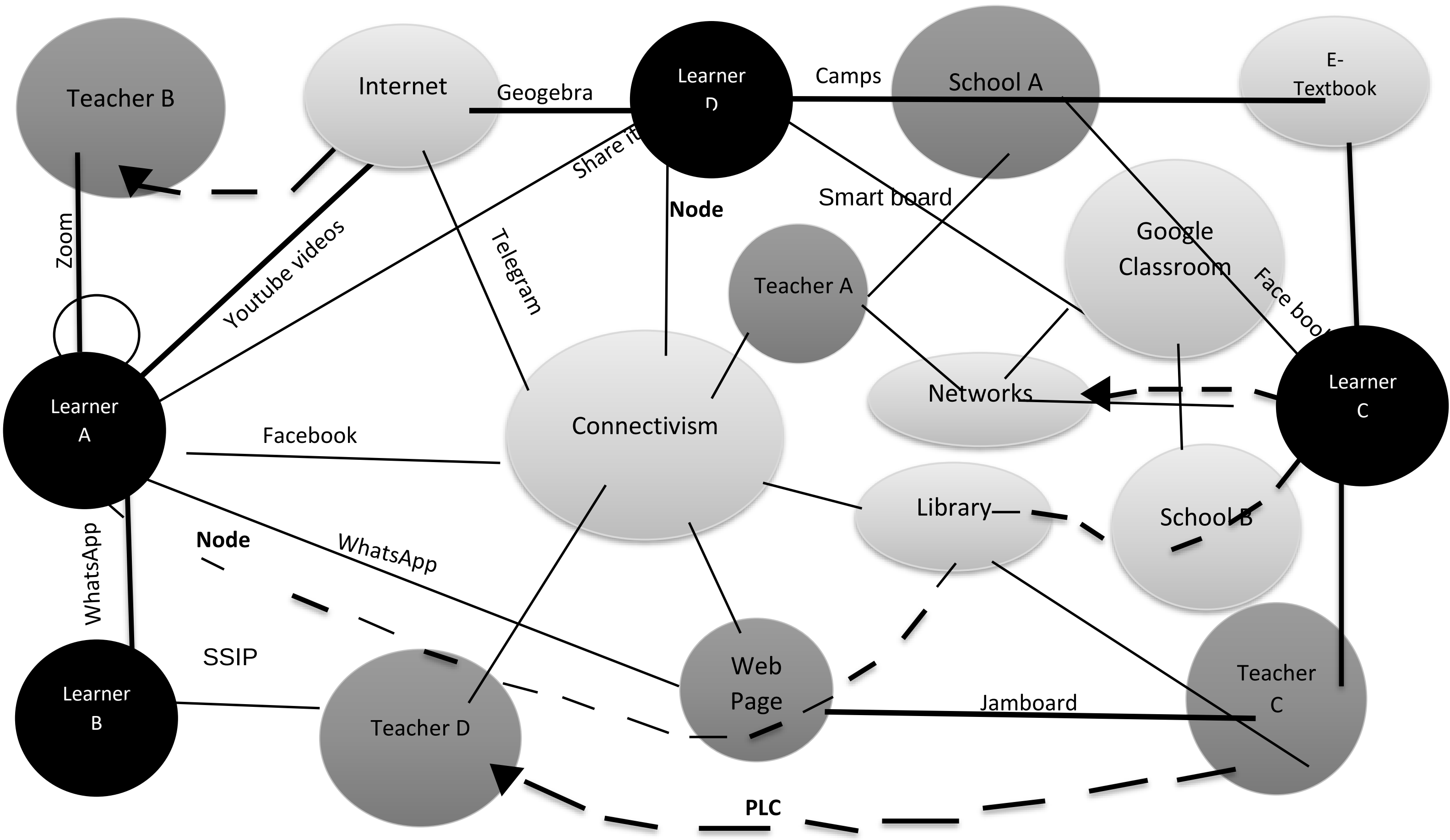



**Figure 5.1 Support connections**

The connections created in Figure 5.1 shows five schools under this study which are interconnected and applies both ICT instructional technologies and non-ICT instructional technologies to support progressed learners.

From the above result presentation, there are interlinks among the schools within Circuit 4, which forms study networks. The first network is through PLC meetings. These are Professional Learning Communities of similar subjects within a cluster. These PLCs are subject cluster meetings where teachers share best practices, similar challenges, and strategies to address such challenges. Each subject has its own PLCs and the departmental officials who are referred to as subject advisors are also a part of these learning communities.

These types of networks according to all the participants, use both face-to-face meetings and are interlinked through various digital connections. With the dawn of Covid-19, most of their PLCs are through Microsoft Teams meetings, Zoom meetings and WhatsApp groups. The importance of these types of links as indicated by all the participants, is to identify common challenges in Mathematical teaching, share new ideologies and identify common errors among the learners and find common solutions. These assist in educator capacitation and mentoring especially for newly appointed educators.

The second link or network is demonstrated through SSIP classes where schools are paired, in this instance school A and B attend SSIP classes every Saturday at school A and school C and D both attend at school E. The grouping was done through geographical settings of these schools for ease of accessibility of learners by the Ekurhuleni Education Department. The participants of this study in both cohorts are a part of these extended support sessions teaching learners from various schools.

Another common approach to supporting progressed learners that participants shared is extended contact time (extra lessons) with a particular group of learners or individual learner. This according to participants in Cohort A, are small nodes or networks which are digitally conducted while teachers in Cohort B use small face to face support sessions either as morning or afternoon classes. The common finding is that these learners require extra contact time, continuous assistance and support to enable them to further practice Mathematics.

The third connection is through technological networks as described above. Participants have indicated that these networks such as WhatsApp groups, Facebook, Telegrams and Share it have overlapped to other schools within the cluster and circuit. Some are between friends from various schools, some were created by teachers as class support study groups while some were learners' initiatives.

Figure 5.1 has tied together both digital connections and non-digital connections as support strategies to support progressed learners. There is a common finding among all participants that connectivism is indeed one of the best ideologies which could be utilised to enhance teaching and learning especially in Mathematics to support low ability learners.

## 5.3 ICT AND NON-ICT INSTRUCTIONAL TECHNOLOGY SUPPORT STRATEGIES

As indicated in Figure 5.1, ICT instructional technologies employs the use of digital tools which embed the use of networks, links and nodes for creation of knowledge (Siemens, 2006), in order to facilitate teaching and learning within these networks. In order to support progressed learners, both learners and educators have created these network platforms that assist beyond the normal teaching and learning setting offered in the traditional classroom.

As explained by Griffiths et al. (2021) social network websites are considered as an ideal source that helps learners acquire knowledge. Thus, the field of education has undergone a drastic shift and gained a new dimension over the past decade. This view was shared among participants, that teaching and learning has shifted since the introduction of ICT instructional technologies into their classrooms, to the use of digital social networks to enhance teaching.

Most of the educators indicated that these are the most common social networking platforms and websites learners use to acquire information:

Facebook: As described by Wise et al. (2011), Facebook is a celebrated interpersonal interaction site that has almost a billion clients everywhere in the world. This site is viewed as the best site for advancing schooling. The Facebook platforms are framed for schools and classes and accordingly the site permits both the educators and learners to share their data, post questions and replies, set updates about forthcoming occasions, and so on. The most common Facebook platforms that are accessible are Wiki-educators , E-Learning in developing and developed countries, Teaching Critical Thinking and Active Learning, and the majority of participants indicated that their learners use these platforms.

WhatsApp, Share It and Telegram are social network platforms that only assist learners with collaboration and communicating ideas. They do not offer researchable sites which offers new knowledge. Despite this shortcoming, its usage was deemed the most popular among learners; about 95% of the learners in the Grade 12 classes in the sampled schools are in a WhatsApp group.

Microsoft Teams and Zoom: These social network platforms were viewed as least popular because they require a scheduled time for all participants to take part in a discussion. As Siemens (2006) indicates, connectivism allows learning to happen at any given time and learners should be free to access information at any given time.

The findings further indicate the level of popularity in terms of usage of different applications. WhatsApp, Facebook and Telegram were found to be the most popular while Zoom and

Microsoft Teams were the least used. Participants indicated that both Zoom and Microsoft Teams are not as popular because learners have to set a specific time frame to participate while other social network platforms are always accessible to them. Rambe and Bere (2013, p.145) produced similar findings in a study they conducted using 163 higher education learners they found that: *"WhatsApp positively influence students' ability to participate and connect with peers online at any time, their online interactions are flexible in comparison to the formal lectures".* Siemens (2006) indicates that connectivism allows its users freedom to choose what to learn and when to learn. These two social network platforms were mostly used in informal set-ups, with fewer learners for special cases such as when a learner was in quarantine or absent from school due to a valid reason.

Although there were other applications used, the above were the most common among the participants. These are informal social networks created by either educators or learners to assist in the process of knowledge formation. The applications as reiterated by all participants are commonly utilized networks that facilitate information sharing and development. These connections are between learners of a particular school under study while others are formed between learners living in the same area.

Siemens (2006) indicates that the evolution of education through the digital age calls for creativity in applications that will transfer the benefits of teaching and learning. This view was shared by most of the participants. These platforms served as discussion forums where learners exchange ideas, create new information and disseminate it. According to Ketelhut and Schifter (2011), the use of social network platforms assists in knowledge sharing and creation within learning communities. All the participants acknowledged that the platforms are available and functional within the classrooms and educators had to take advantage of their existence and use it to the learners' benefit.

On the other hand, a second set of findings indicated a group of educators who believed in face-to-face interactions through the use of extra lessons for progressed learners. These lessons are offered either in the mornings, afternoons or Saturdays. There are other programmes such as SSIP and school holiday camps which are offered by both schools with the support of the Department of Education in the province as support strategies. These participants believed in concentrating on low level questions which they believe that if drilled thoroughly, a learner may be able to attain a minimal score as opposed to the teachers who were interviewed who allow learners to decide what, when and how they want to learn.

## 5.4 TYPES OF DIGITAL NETWORKS USED TO SUPPORT PROGRESSED LEARNERS AT THE PARTICIPANTS SCHOOLS

The findings of this study indicate that, for all participants, there is a common instruction or policy which dictates that learners must be progressed, but it does not clearly define how learners must be supported and at which specific time or what type of content is required. It is up to certain individual schools with the existing resources at the particular teacher's disposal to decide what needs to be done, how and when. This is evident through the various applications educators use, their degree of usage and availability in each individual school. There are aspects which further influence networks created, or support strategies adopted in each school. In the case of the first cohort of educators who were interviewed, the integration of ICT instructional technologies into teaching and learning according to Rabah (2015) must take into consideration a myriad of aspects such as the structural aspects, the distribution of classroom space, availability and maintenance of ICT resources and the support thereof.

This ideology to a large extent was cited as critical by all participants in terms of ICT rollout in schools. Each school provides a computer or a laptop to their matric students; two schools indicated to have given each learner a tablet that is loaded with CAPS content and e-books. As indicated by Rabah (2015), these schools do not have a common practice in terms of ICT rollout. Although all participants reported the use of interactive white boards in each class, which are also loaded with relevant curriculum content, the extent of usage and maintenance varies according to schools.

Another device often used are learners' cellular phones. Participants indicated that their schools encourage learners to bring cell phones to school as part of their ICT policy, and they are given access to download the school curriculum. This policy was introduced by each school to reduce the lack of resources they were experiencing. ICT integration in schools requires a large investment and policy changes and support by management for its incorporation into teaching and learning (Christensen et al., 2018). All the participants reiterated this view, but they indicated that most of these connections were informally established and there was not much support from the Department or school management teams.

Most participants indicated that the management buy-in was obtained at a later stage of their implementation. The participants further outlined that they have created networks from the limited resources at their disposal that extends teaching and learning beyond the classrooms. According to Christensen et al. (2018) the lack of technological infrastructure in some school's act as a hindrance towards full ICT implementation, creating a gap between the haves and the have-nots. This disparity is further cited by Sinyosi (2015) when she outlines that the difference in learner attainment within South African schools is due to the resource distribution, with rural schools or township schools not having access to more resources as compared to their ex-model C (urban) counterparts.

### 5.5 THE EFFECTIVENESS OF SUPPORT STRATEGIES FOR PROGRESSED LEARNERS

The findings of this study indicate that although a number of educators interviewed in Zimasa (2016) blamed progression policy for a high failure rate, the DBE (2020) report as outlined earlier, paints a different picture of several progressed learners passing Grade 12, and some even obtaining distinctions in Mathematics. The findings from the participants indicated far-reaching benefits or positive impacts of using ICT instructional technologies in connectivism in this study as opposed to face-to-face extra lessons as indicated by participants in Cohort B.

The findings from Cohort A teachers indicated that the use of ICT instructional technologies as a support strategy have generated much interest amongst learners as opposed to the traditional extra lesson support strategies. This is similar to the study conducted by Alfaki and Alharthy (2014) studying the impact of social networks in teaching and learning. Their findings indicated that learning using social networks was more effective than the old classroom methods used. As indicated by Bansal (2016) the younger generation has shown great interest in the creativity technology has introduced into their lives. All the participants in cohort A, shared the notion that their learners' interest in participating in digital class activities has improved compared to the traditional teaching methods. Looking at the findings from Cohort B, one finds that their support strategies are not as impactful as opposed to Cohort A.

Cohort A teachers noted that they relied more on peer education, collaborative and discovery learning, and learners quick to assist each other to solve problems, and this is seen through their social media group discussions. This finding is in line with Bouhnik and Deshen (2014) in determining the effectiveness of WhatsApp in the learning process.

The findings of this study have further indicated that the role of the learners has shifted to information creators which enhances collaborative learning in Cohort A while learners supported by Cohort B teachers still depend on the traditional way of drill and practise in face-to-face support sessions. Chugh and Ruhi (2018) further assert that technology has enabled sharing of inventions globally and this view was echoed by all participants, that most learners are willing to share what they have discovered with their peers.

Cohort A learners learn though a connectivism type of learning which encourages corporative and collaborative learning (Downes, 2016). One of the most important aspects of networks as indicated by Downes is the idea of collaboration and sharing of inventions. This view was common among the participants from Cohort A as they indicated that peer-to-peer collaboration has improved and there is a joint understanding and collaboration within these networks. They noted that learners work better in groups to create knowledge. As described by Wise et al. (2011), social networking sites assist individual learners further through the following ways, and these were also common findings in this study:

- to enhance creativity
- increase learners' communication skills
- create collaborations and teamwork among networks
- offer access to information
- raise awareness on issues
- develops social connections.

All the participants in Cohort A shared Claro et al. (2018)'s view that learners can improve their communication skills, enhance their technological ability, connect with the world and expand learning.

The study further found that not only do learners benefit from these networks but so do teachers. All the participants reiterated that these new sites learners discover, at times require a teacher to explore and learn with the learners. The list below is some of the benefits found in this study as indicated by all the participants and supported by a study conducted by Paat and Markham (2021):

- increased resource accessibility
- collaborate with different teachers
- exchange data and lesson plans
- reach parents or guardians when the need arises
- create working partnerships with other schools locally or outside the country.

It is not difficult to access and use networking sites from anywhere on the planet and whenever they have acquired fame among learners (Paat & Markham, 2021). Additionally, online media sites give a huge measure of information valuable to teachers, and along these lines cause capable learners to separate what information is helpful for them, and what is not. Notwithstanding, it is advancing education among learners, further assists learners in subject choice selection as it exposes learners to what careers are emerging in the job market. In this manner, networking sites do not only connect people but further advance educational benefits.

Moreover, connectivism as a support strategy encourages higher order thinking, as Siemens (2006) says; knowledge is not only derived from a single source but from multiple sources. In this study participants indicated that learners come up with multiple solutions to their Mathematics problems. This has assisted progressed learners because they have multiple choices of using a method they are most comfortable with, unlike face-to-face sessions which basically are still more teacher centred.

Downes (2016) further says connectivism types of learning allows a community of people working together to legitimize what they are learning, and the participants of this study indicated that these social media groups which have been created assist each other to legitimize their learning content. It further generates a variety of ideas as learners consult a wide range of sources. Ohler (2013) argues that the discovery of multiple ideas from a variety of sources makes learning fascinating and effective.

Another view which participants shared with Sahni (2016) is that learning, either formal or informal, is effective and ICT instructional technologies are applicable in both set-ups. All participants indicated that learners are more comfortable learning in a relaxed informal set up at home while teachers in Cohort B indicated that their progressed learners lack commitment which results in poor participation or poor attendance of extra classes. The researcher further found that there is no variety of teaching methods applied by Cohort B teachers as they still maintain the same strategies as the ones applied in the classroom, hence a low possibility of any impact towards the learners.

In order to ascertain the effectiveness of the support strategies, the researcher further investigated the frequency of the network usage, how they are being applied in a lesson from the Cohort A teachers and this was compared to the Cohort B support strategies. As Walker et al. (2017) indicates, for connectivism networks to be effective there should be a significant number of users in these social networks who fully participate. Of the ten participants in Cohort A, eight have indicated a participation of at least above 60% while only two indicated a participation of at least 50% while Cohort B teachers indicated poor attendance to either extra classes or SSIP Saturday classes. One shortcoming was that teachers could only estimate the level of participation; the framework created gives teachers a better option to monitor the exact number of participants within a network.

Another finding from cohort A teachers was that these networks do not only occur within the school setting, but they have also extended into interschools, districts and provinces. Smidt et al. (2017) note that teaching and learning with ICTs instructional technologies should not only be confined within a formal classroom setting. This idea was shared by participants in Cohort B that SSIP and camps create study networks, learners from different schools come together to engage in the learning process on weekends or at camps. This means connectivism allows for continuous learning beyond the classroom (Siemens, 2005) using various data sources. One believes that, if extra classes are combined into, or are a part of these networks, and offers a learner an opportunity to attend them online, the level of attendance may improve.

There were varying opinions from participants on which part of the lessons where ICT instructional technologies when incorporated, would be most effective. The most common use is giving homework and reinforcement as drill and practise as indicated by the participants in this study. This homework is accessed through digital links such as Google classroom and are shared among networks and offer repeated practise.  Smidt et al. (2017) indicate that learners learn more effectively with constant practise and according to the participants, this is more common using these networks. This view was further shared by Cohort B teachers who believe that the extra lessons offer drill and practise and repetitive learning.

Another common way to integrate ICT instructional technologies into the lesson is when introducing the concept. Several participants indicated that this captures the learners' attention. It enhances discourse, and this notion is further supported by Alzain (2019) by indicating that discovery learning is very effective as it increases the learners' eagerness to find their own solutions.

All the participants reiterated that they use smaller grouping for the purpose of reinforcement and drill and practise, and this view was shared by participants in both cohorts.

Participants in Cohort A have also indicated that they use ICT instructional technologies to introduce new concepts, to reinforce teaching, to offer multiple solutions and to increase learner engagements through research. Learners are required to go into their research groups and find information on the new concepts and share it with the rest of the network or class. This enables the learners to study the concept further and make presentations and assist other learners who may be experiencing some challenges (Sahni, 2016). The introduction of these multiple teaching approaches has been argued to benefit low ability learners by participants in Cohort A.

Participants in Cohort A have argued that certain ICT instructional technology applications offer instant feedback and tutorial corrections or illustrations, pause and rewind which then assist progressed learners to master concepts. Dagli et al. (2020) share the view that images, videos and virtual realities act as clear demonstrations of complex concepts for easy illustrations.

## 5.6 THE BENEFITS OF USING CONNECTIVISM IN ICT NETWORKS TO SUPPORT PROGRESSED LEARNERS IN MATHEMATICS

One of the study's objectives is to describe the benefits of using connectivism theory in ICT instructional technologies to support progressed learners. The following findings illustrate that ICT instructional technologies played a very vital role in the following ways.

It was commonly acknowledged by Cohort A teachers that ICT instructional technologies offer individualised support for various learners. Progressed learners are given an opportunity to fully be involved in the process of knowledge development and dissemination. Individualised learning offered by various webpages offers an extended support which is shared among these connections. Learners create knowledge and opinions that are diverse (Trna & Trnova, 2012). This is found to be of benefit to progressed learners as they are offered varying options of problem-solving.

As outlined in the United Nations convention on Children's Rights, all children have the right to education and to attain their full potential and this encompasses inclusive and equal quality education (Pitchford & Outhwaite, 2019). To attain this, effective and practical observable interventions that can offer support to low ability learners in Mathematics should be introduced in schools. These include the introduction of Mathematical apps (Herodotou, 2018).

There is significant evidence from the participants that digital applications have contributed immensely to Mathematics knowledge acquisition. The participants shared Pitchford and Outhwaite's (2019) view that Mathematics applications offer greater gains using handheld touch-screen gadgets such as tablets or laptops. They are interactive; they are learner-centred as compared to traditional teacher classroom practices (Xie et al., 2018). Participants in Cohort A use teaching aids such as Jamboard, Desmos and Geogebra applications which makes Mathematics learning more concrete than the traditional way which was quite abstract. These assist progressed learners in understanding concepts such as graphs.

The findings from this study are similar to the findings of a study conducted by Outhwaite et al. (2017) in Brazil. Evidence from this study indicates that app-based learning can enhance “domain-specific Mathematics skills for low ability learners” and it could be a solution to support slow or low ability learners. This view was further supported by Pitchford and Outhwaite (2019, p. 2) by indicating that reasonable evidence from research shows that “visual attention, short-term memory and processing and speed are associated with early Mathematical development”.

Further research findings, similar to the participants’ views, are echoed by Hirsh-Pasek et al. (2019) that high quality digital instruction has indicated there is a meaningful learner engagement, direct engagement with real objects and numerical representation, which influences the learner’s ability to support Mathematical growth in a technological teaching and learning set-up. With the commonality of their support strategies, teachers in Cohort A have shifted a lot towards a connectivism way of teaching.

Similar findings to this study were further echoed by Moyer-Packenhan and Sue (2012) by outlining the following benefits for not only low ability learners but all learners. Teaching apps offer immediate feedback (either positive or negative) and rewards. They enhance continuity to higher order levels, support motivational enhancement for struggling learners, and improve social interactions. Overall, as outlined by the participants and Gray (2015), many Mathematical apps give dependable feedback and incentives. They offer self-controlled learning, choice and a self-regulated scaffolded type of learning. These findings were reiterated by the participants in this study.

As indicated by Downes (2016), learning is obtained from non-human appliances. Progressed learners require a variety of information from information sources such as websites and libraries that assist them to comprehend concepts. The tutorials, videos and simulations assist them to understand certain concepts. They learn through demonstrations, concrete models and participation in virtual worlds. This was one of the shortcomings from the Cohort B teachers who only depend on extra lessons which are face-to-face and do not tap into other knowledge sources.

Another common finding is that teaching and learning have become learner-centred as per participants in Cohort A. Connectivism allows learning to be controlled and managed by learners within the networks (Kizito, 2016). All participants shared this view as they reiterated that peer learning was enhanced as learners controlled and participated in knowledge formation. They choose what to learn and ways in which they prefer to learn, and this is fully supported by connectivism theory.

Another finding among the participants is that when ICT is used in a connectivism ideology, it enhances collaborative learning. Learners connect to a network to share and get new knowledge (Kop & Hill, 2008). Collaborative learning allows multiple ideas to be disseminated and learners together contribute towards knowledge formation. Information does not rely on a single source; it could be derived from fellow learners, teachers, or websites.

Learners and teachers work collaboratively to create and disseminate knowledge as opposed to cohort B's way of teaching where teaching and knowledge creation still to a large extent relies on a teacher. Teaching with ICT instructional technologies gives room for discourse, giving progressed learners an opportunity to be a part of a learning process (Andyani et al., 2020). All participants have observed that this type of learning promotes higher order-thinking, as compared to other teaching methods where learners are passive participants, as indicated by Andyani et al. (2020) and this view is achieved through digital connections among participants and their learners in both cohorts. Various websites offer high level information which prompts a higher level of thinking and analysis. There is an exchange of ideas, constant discussions and feedback obtained through networks. As outlined by all the participants, each idea or viewpoint is scrutinized, developed and shared to a larger network.

Progressed learners learn at their own comfortable pace when they learn through ICT instructional technologies as opposed to the traditional classroom extra lessons. But one critical finding was that for both cohorts, the CAPS syllabus is highly congested making their completion very challenging. The network platforms and extra classes offered, such as SSIP and camp classes, offer expanded opportunities for learners to revisit certain concepts that are challenging, and which an educator cannot cover thoroughly in a traditional classroom. These platforms are not time bound (Meyer & Gent, 2016); a learner can go into these links at any given time and learning becomes continuous.

One of the most common benefits all participants shared is that information is generated from multiple sources; it becomes easier for a progressed learner to compare methods and solutions while creating his or her own understanding. Participants further shared a view that these networks also offer the opportunity for cross referencing as learners compare their findings with their networks either in SSIP classes, or digital network discussions.

With connectivism, teaching and learning can happen anytime and anywhere. Covid-19 forced countries into lockdown, so the introduction of connectivism with digital learning became a solution to ensure that teaching and learning continued. Schools depended solely on learning networks to facilitate the process of learning. Learners did not lose much contact time as teaching and learning were carried out through networks. “The cycle of knowledge development allows learners to remain current in their field through formed connections” (Siemens, 2005, p. 4).

Participants in Cohort A indicated that connectivism and ICT instructional technologies improved remote learning. All participants in Cohort A reiterated that to ensure the implementation of Covid-19 rules and their adherence, ICT instructional technology played a vital role in driving the process of learning. Learning occurred beyond the classroom. This view was shared by Thomson (2020), when he indicated that ICTs have allowed teaching and learning to take place beyond the formal confines of a classroom which did not seem to be a case with Cohort B teachers.

The school system changed after lockdown. There were systems that were put in place to ensure that Covid-19 rules were adhered to. The first was a rotational timetable. Learners were given specific days to come to school, only a few could be accommodated in a single day to ensure social distancing, and these included progressed learners. Downes (2016) asserts that connectivism encourages remote learning; learning is no longer confined to a classroom (Plumb, 2017). This then meant that some learners would, on certain days, stay at home and study remotely to ensure social distancing. Connectivism then played a bigger role in ensuring that these learners were still a part of the learning process.

The second occurrence was learners who were in isolation or quarantine. According to DBE (2020), it was a requirement that learners had to stay at home or at quarantine centres for 10 to 14 days without attending school. Lessons were loaded on their applications and sent to them. They engaged in class discussions through Microsoft Teams or Zoom and at times engaged in information sharing with their networks using WhatsApp, Facebook or Telegram. Jackson (2020) reiterates that ICTs have broken the barriers that forced teaching and learning to be purely classroom based.

Most of the participants in Cohort A agreed that connectivism allowed for flexibility and creativity. The ability of learners to find relevant and current knowledge sources, create and participate in networks and identify which information to use, calls for a level of flexibility and creativity. This notion is supported by Kop and Hill (2008, p. 6) by indicating "the ability to build and traverse networks constitute the learning process".

Comparing the above findings with the findings from Cohort B teachers, one notes that these educators apply the extra lessons as their core strategy to reinforce certain important concepts. Their ultimate goal is to ensure that these learners attain at least a 30% pass mark which is a minimum requirement to pass NCS. According to participants, the benefits of this strategy are not noteworthy, although there are some learners who ultimately attain good marks.

### 5.7 THE EFFECTIVENESS OF THE USE OF ICT INSTRUCTIONAL TECHNOLOGIES IN CONNECTIVISM NETWORKS FORMED

Another finding in this study investigated the effectiveness of the networks created. Of the ten participants sampled for Cohort A, two participants indicated that most of their learners participated in the digital networks. It was estimated that there was at least 95% participation while two participants indicated an average participation of 50%. Reasons given for higher participation included the availability of Wi-Fi connectivity at these two schools; learners were given tablets and using them as learning tools was compulsory. Despite the low usage by other participants' schools, one shared view was that their benefits were visible.

As indicated by Siemens (2005), connectivism is a theory developed to facilitate teaching and learning in the digital age. It allows for remote learning. Learners can learn anytime and anywhere. Its effectiveness has been established in this study. The schools have IWBs that have access to internet which has therefore made it easy for learners to research a concept under discussion right in class, making knowledge not only derived from humans, but also from other sources (Downes, 2007).

Learners are linked to the IWBs through Bluetooth which makes note taking easier and faster. The number of learners participating in this type of learning is quite high but varies in schools. Many learners in the school where Participants C and H were interviewed revealed a large participation while some schools indicated an average participation. These platforms are very effective, live and there are constant discussions going on even at odd hours.

The following were cited as visible effects. Learners come up with well-researched content, their schoolwork participation has increased, cooperative learning has increased and they obtain instant feedback rather than waiting for an educator to establish which answer is correct or incorrect. In the research that Alkamel et al. (2018) carried out in three countries, he indicated that learners achieved a great improvement when using mobile technologies. This study was further supported by (Kizito, 2016)'s investigation of teaching with wireless technologies, and the findings revealed that using digital devices was an effective educational tool that influenced learner attainment positively.

Another major finding was the ability to consult multiple sources as advocated by connectivist scholars (Kop & Hill, 2008; Kizito, 2016; Siemens, 2005; Downes, 2016). Learners do not only rely on the educator as the information source but there are also multiple sources from which learners can derive their knowledge. These sources provide simplified methods for easy comprehension of progressed learners. This on its own is a support strategy that assists low ability learners to understand concepts.

It was further found that learners are in control of the information they develop, teaching and learning has become learner centred, learners choose which information they want and how and where they obtain it. This means that learners can explore their various networks and the type of information they use on their own.

## 5.8 THE IMPACT OF SUPPORT STRATEGIES ON PROGRESSED LEARNERS

One of the objectives of this study was to track the performance of learners who were progressed and were supported using ICT instructional technologies in connectivism networks and non-ICT intervention strategies.

The findings indicated that the introduction of networks improved learners' participation in the process of learning. Siemens (2005) denotes that active networks contribute to sharing of ideas to a larger community. Participants in Cohort A indicated an increase in discussions within networks, as compared to the extra class discussions where low ability learners are passive or not willing to be involved. Most participants interviewed indicated that learners are not shy to share their findings or reasons for the methods they used in their small digital learning networks.

Secondly, learner interest and concentration has improved, as opposed to Cohort B teachers who reported a low attendance and poor participation by learners. Participants in Cohort A indicated that the use of searches from websites has made learners participate fully in the process of learning; their ability to come up with new information, back up their findings and engage in discussions has improved class participation.  Their research skills have improved, and they are allowed to use code names, so the issue of being ridiculed if they get a concept wrong is minimized, which then improves their participation.

Moreover, as indicated earlier by participants in Cohort A, connectivism allows people to form personal networks, thereby improving learners' social skills and interactions. Being able to participate in a study network and collaborate in the information production, improves ones interpersonal, communication and social skills. These skills will be needed to function in their adult life.

Thirdly, learner attainment in these schools has improved from Term 4 2019 to Term 3 2020. Looking at the various tracking tools, it is apparent that there was a gradual improvement of learner performance throughout the three terms, and this was due to the support progressed learners attained from their study networks for three teachers in Cohort A participant's school. This is in contrast with the Cohort B schools, all the six participants indicated an attainment of 30% at the preliminary exams. This is not a surprise as one of their strategies is to concentrate on the low level questions which only add up to a 30% pass mark hence their end of year attainment is at 30%.

## 5.9 LEARNERS REACTION TOWARDS LEARNING WITH ICTS INSTRUCTIONAL TECHNOLOGIES AND NON-ICT INSTRUCTIONAL TECHNOLOGIES

Six of the ten participants in Cohort A shared that network learning inspired learners to participate and the availability of various sources of data has built a confidence to be a part of learning. Samarakoon et al. (2017) argue that technology improves interest in learning and this view was shared by all participants that learners have developed a sense of adaptability and interest in remote learning, which is not found in the classroom setting, and they are more at ease with finding their own information and sharing it. This view differs with that of teachers in Cohort B who indicated a low attendance and lack of interest they have observed among their learners who are progressed.

As outlined by participants in Cohort A, the ability to find a variety of resources keeps learners more engaged and they participate more in networks than in the classroom setting. This view is supported by Kizito (2016) who indicates the following findings on the impact of networks: increase in participation, enhanced collaboration, improved learner interactivity, creativity, community building, sharing, networking, flexibility and customization.

## 5.10 CHALLENGES OF SUPPORTING PROGRESSED LEARNERS USING ICT AND NON-ICT INSTRUCTIONAL TECHNOLOGIES

Finally, one of the objectives of this study was to find out the challenges faced when using ICTs in a connectivism theory to support progressed learners. It has been established by all participants in both cohorts that not all learners participate in these networks either digitally or in extra lessons, and the common reason being lack of resources. Hinostroza, (2018) shares this view that the availability of resources plays a major role in the rollout of ICTs into schools. Cohort A teachers raised issues of connectivity while Cohort B teachers indicated that learners having to travel to SSIP classes on Saturdays and some having to pay for transport was a problem. Looking at ICT resources, unfortunately, according to the participants in Cohort A, the rollout of ICTs into their schools is not yet a priority; educators make use of the limited available resources. These limited resources are either technological or connectivity for learners from disadvantaged backgrounds. These learners are unable to be a part of important discussions and may not benefit fully. It was found that some learners must stay behind at school quite late to make use of the free school Wi-Fi, as they do not have connectivity at home, hence missing out on afternoon discussions or online homework given.

Another common challenge among Cohort A participants is poor monitoring. Martin and Tapp (2019) outline the following negative effects of social media on education and their findings are in line with the participants' views of poor or minimal monitoring. They believe that if ICT instructional technology applications are not properly managed it may cause a distraction for learners. Another point of serious concern is the issue of privacy and learners being exposed to misleading and incorrect information which may be very challenging to unlearn.

Another challenge is learners who may not like to be a part of networks, and this disadvantages them. Two participants indicated that some of the learners do not believe in the use of networks as study platforms and have removed themselves from these groups. This finding is similar to the Cohort B teachers who indicated that these learners lack commitment to attend support sessions and there is no parental support to assist in proper class attendance. These learners therefore miss out on critical discussions as schools do not have policies that force learners to be a part of any network; it is on a voluntary basis.

Thirdly, lack of know-how by educators which ultimately leads to poor participation or poor monitoring by educators of these networks. According to participants, some of these networks are created and managed by learners and educators may not even be aware of their existence hence minimal monitoring. This poses a threat of sharing the wrong information, bullying and misuse of other inappropriate websites. According to DBE (2011), the schools' computer centres should be continuously monitored by educators and certain websites must be blocked, but this can only apply at school and learners may still have free access to their personal gadgets at home to use these networks.

## 5.11 LESSON PLANS AND POLICIES

Looking at various educators' lesson plans and policies used, it is a common finding that the CAPS policy is designed to allow each educator to accommodate ICTs and connectivism. It does not, however specify exactly how it should be incorporated. It rests upon each school or each educator to choose in which part of the lesson it needs to be included. According to the reviewed lesson plans, most educators prefer to use it as part of learner activities while some use it as expanded opportunities that can also work as home activities.

There is no uniformity within an individual school. It was found that teachers' lesson plans allow the inclusion of ICTs and connectivism to be incorporated but it is up to each educator to see where it can be applied. Some participants prefer to use it to extend beyond the classroom as part of homework and reinforcement, while others prefer to use it as part of the lesson in the classroom. This is the same finding with Cohort B teachers who indicated that there is so uniformity within the extra class timetables. Some teachers prefer to stay afternoons to support their learners while some prefer to use early morning lessons as extra support lessons.

A number of participants indicated that support strategies allow learners to tap into their networks beyond a single school and gather a variety of data. Using small groups further encourages learners to form their own communities of learning within a single school or between two or three schools. Whichever way they are used, one can then determine that these networks are available and functional.

Looking at the legal framework guiding the progression policy, DBE (2020) instructs schools to support progressed learners and they have introduced Saturday support classes where Grade 12 learners can be assisted. There are also several circulars such as Circular E 22 of 2016 and Circular E35 of 2015 and the examination instruction of 2015 that gives direction on how learners should be progressed in the FET phase, but there is no specific curriculum for progressed learners. The expectation is that these learners should be supported to be on par with high ability learners because they will be expected to sit for the same Grade 12 examination with high ability learners.

## 5.12 CONCLUSION

This study aimed to find out strategies which can be used to support progressed learners in Grade 12 Mathematics using the connectivism theory. One can then draw the conclusion that there are potential strategies which are ICT instructional technologies and non-ICT strategies which could be used to assist the process of teaching and learning in a connectivism classroom to support progressed learners.

The study described the types of connections used to support progressed learners and it was discovered that in the five schools used, there exists both digital networks and non-digital networks which work towards supporting progressed learners. These are using digital applications to link study groups and physical networks and communities of learning created by participants and their learners to support learning.

The study further aimed at finding out the type of digital networks that assist in supporting progressed learners. Social networks such as WhatsApp, Facebook, Google classrooms, Microsoft Teams, Zoom and Telegram are the most common digital links that learners use to network in the process of teaching and learning. The other finding for this study was the face-to-face support networks created such as PLCs, SSIP and camp classes which are also used as support strategies for progressed learners. These networks are functioning both formally and informally. One can then conclude that the available study networks play a critical role in assisting and supporting progressed learners.

In assessing the effectiveness of digital networks as support strategies teachers use, one can conclude that the findings illustrate the level of effectiveness in terms of their usage and the results yielded thereof. In some schools, the level of usage is very high meaning most learners do benefit from these strategies while in a few schools the usage is average. Looking at the learners' participation and performance, one can then draw the conclusion that connectivism when used with ICT is effective in supporting progressed learners as opposed to the traditional extra lessons where learners still rely on the same classroom educator.

Another objective of this study was to track the performance of progressed learners supported using various educators' strategies. From the findings, learners' performance has improved throughout the terms for Cohort A participants and one of the effective strategies used to attain good results was the use of ICT instruction technologies. There was a gradual improvement throughout the four terms for first cohort participants' learners, which were tracked in the study, and this could ultimately indicate that connectivism used with ICTs has the potential to be a very good strategy in improving performance of progressed learners. On the other hand, one can draw a conclusion that face-to-face support initiatives yielded minimal results as opposed to the ICT instructional technology support strategies.

The study further investigated the challenges teachers encounter in supporting progressed learners in Mathematics. It can be concluded that the lack of resources such as digital devices and connectivity is a big concern for the teachers in Cohort A while poor attendance and lack of commitment is a big challenge or Cohort B teachers. Secondly, the proper alignment of annual teaching plans to support the new strategies should be encouraged. The findings indicate that it rests upon each school to devise means to support progressed learners, as there is no printed guide from the Department of Education on how to do so. It is a policy issue that should be addressed by the policy makers. Other challenges that were cited were the lack of interest among some learners that reduced the number of learners involved and the issues of bullying and misuse of information.

One can conclude that connectivism does play a pivotal role in supporting progressed learners. It has provided them with an opportunity to learn differently, at their own pace and offers a choice on how and when they prefer to learn. From the above analysis, one can then draw a conclusion that although there are challenges which need to be addressed by the policy makers, the benefits are clearly visible. The importance of ICTs used within connectivism has been established and it is therefore a requirement that technological resources should be a priority in schools.

It is based on these findings that the researcher designed a support framework for progressed learners which includes both ICT instructional technologies and non-ICT to support progressed learners. The following Chapter six offers a recommended framework which could be used to answer the problem of supporting progressed learners. This framework uses the best practices derived from the research findings and creates a link between both cohorts of participants embedding all connections and their support strategies. This framework best suits both learners from either resourced or less resourced schools.

# CHAPTER 6: SUPPORT STRATEGY FRAMEWORK

## 6.1 INTRODUCTION

The findings of this study have influenced the development of a framework that has incorporated all the strategies and good practices obtained from the participants of this study. This digital framework encompasses both traditional support strategies and ICT instructional technologies using connectivism. This framework consists of twelve illustrations which outlines remote digital support learning, SSIP and learning through connectivism theory.

The framework is intended to bring uniformity among all schools in terms of support strategies and a guide which both accommodates ICT instructional technologies and non-ICT instructional technologies.

## 6.2 THEORETICAL DEVELOPMENT OF A PROTOTYPE

| **Insights from literature on progressed learners** | **Recommendation for prototype** | **Theory/ Literature** |
|---|---|---|
| 1. Research indicates that low ability learners have shown a gap in content from previous years. | It is recommended that there should be activities or demos from previous grades which a learner may cross reference. | Chen et al., (2009), indicates that in cognitive theories, performance when learning relies on the ability to process prior knowledge to build new knowledge. Learners will be able to create links with what they already understand to the newly acquired knowledge and be able to apply it. |
| 2. The study has indicated a dilemma educator's face, of a learner population which is diverse through | To respond to this challenge there is a need for curriculum differentiation, a notion advocated within a variety of videos and tutorials within the prototype. | To answer to learners who are academically diverse, differentiation pedagogy must be advocated to accommodate both high |

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| learning space, cultural background, ethnicity, economic ability and learning approaches. | | ability and low ability learners (Hobson, 2008). |
| 3. The class size and educator speed in an attempt to complete the syllabus was raised by participants as a negative impact towards progressed learners. | The prototype offers an individualized pace managed solution where learners can engage in their own time, pace and grouping. | Fatonia et al. (2020) recommends that for online learning to be effective, one must investigate the following: speed, pedagogy, the role of a teacher, sources of feedback and the online learner role. |
| 4. According to Fatonia et al. (2020), a classroom at times becomes a complex environment for learning. This is a view shared by participants in relation to progressed learners. | The prototype offers a remote learning space where a learner can learn in the comfort of his / her home and engage a teacher privately. | Fatoni et al. (2020) argue that online learning can become a solution. |
| 5. In 2020, the world was shattered by the Covid 19-pandemic, the hardest hit was | The prototype then becomes more of a need, rather than just an add-on as a requirement in situations as dire as that | When the 2020 NCS cohort began their final year, their challenges were greater than that of their counterparts from |

| | | |
|---|---|---|
| 2020 NCS learners who required extra support. | of the 2020 pandemic, to ensure that progressed learners receive constant support. | prior years. As explained by Dube and Ndaba (2021), there was a need for a shift from the traditional way of teaching to an online method. |
| 6. Participants stated a preference for game-like demonstration simulations or a concrete way of teaching Mathematics. | An easier way to study geometry was to use GeoGebra applications to demonstrate the behaviour of graphs and the prototype responded to this need. | Fauzan et al. (2002) indicate that a realistic Mathematics approach means Mathematics is done by solving real, daily life problems and teaching and learning requires a level of interaction among learners. |
| 7. Insights from the research indicate a need for peer education as an aid for progressed learners in the process of learning. | The prototype should allow for peer group discussion and interactive workspaces. | RME philosophy advocates a learning environment which enhances discussions and reflections in the learning processes. Learners must be encouraged to communicate their thoughts and solutions (Dickison et al., 2012) |
| 8. Participants have indicated that there are a number of support strategies which they have adapted, one being making learning more learner- | The prototype is designed to promote a learning environment which is learner- centred. Presentation from groups is uploaded and shared among learners. | The constructivism theory advocates for a learner-centred approach. It is through discussions, presentations and group work that struggling learners obtain deeper insights which they can |

| | | |
|---|---|---|
| centred where learners support and learn from each other in relaxed peer groups. | | apply to a problem (Faulkenberry & Faulkenberry, 2006). |

### 6.3 FRAMEWORK FUNCTIONALITY

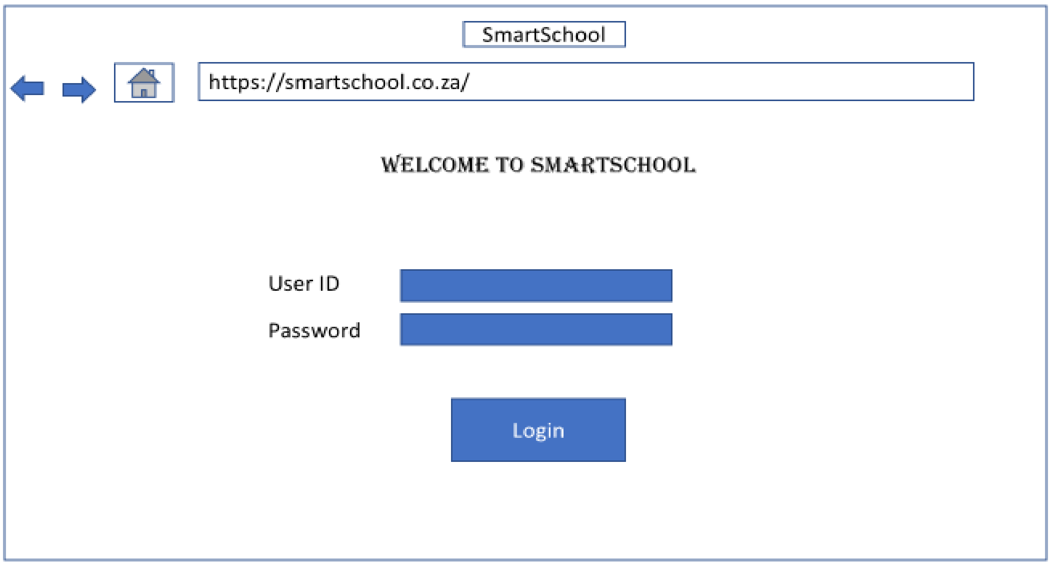
Learners have their unique user ID which could be a student number and a password to log into the application. This application is termed Smart School in this study. It has the home, chat, subjects, timetable, announcement, tracking, monitoring tools and assignment features. Under the subject icon, learners can find all the materials of different subjects, links to tutorials, memos, webpages and past question papers. Educators are able to post live lessons, recorded lessons, SSIP tutors, assignments and marks.

The unique part of this application is that it ensures that a variety of resources are at the learners' disposal. The live lessons which allow a learner to watch in the comfort of their home, a variety of resources from various networks and pre-recorded sessions which allows for rewind, pause or repeat and SSIP lessons which brings learners to other unique learning platforms.

The application has a charts section which is critical because it allows for collaborative and peer learning. It further allows an educator to monitor participation because it indicates the number of learners who have joined the chatroom or have participated. It also offers a workspace which allows learners to post their solutions. There is also a unique icon which indicates the number of views and likes. This icon is made specifically to draw attention to learners who have not participated, the more popular the lesson, the more learners will be inclined to watch. Live charts can also be recorded for future reference enhancing drill and practise.

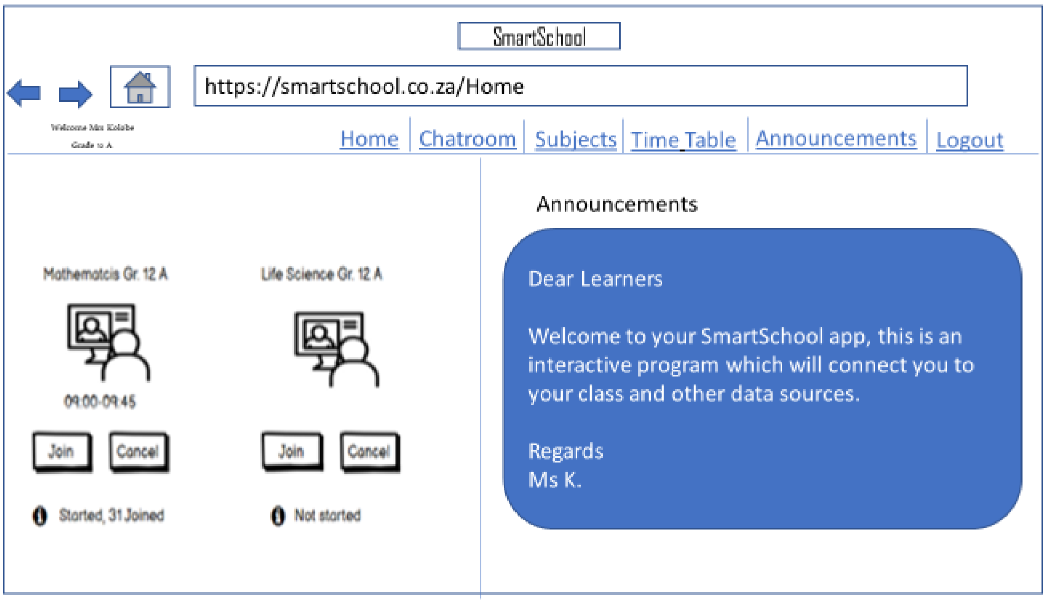
The application contains links to various CAPS resources as a pre-requisite of the Department of Education. Learners will be exposed to E-readers, E-textbooks and other material of importance to support and enhance their learning. The application lastly contains a SSIP portal which embeds all departmental support sessions, in which learners can physically be part of, or watch them live or watch recordings.

The application offers a variety of Mathematical resources, lectures and discussions which are either live or pre-recorded aimed specifically to support progressed learners. It is easy to use, learners can participate in their own time. Video and E-materials are uploaded, and it allows for network connections, and this application will be generally applicable and accessible to all Grade 12 learners in the country.



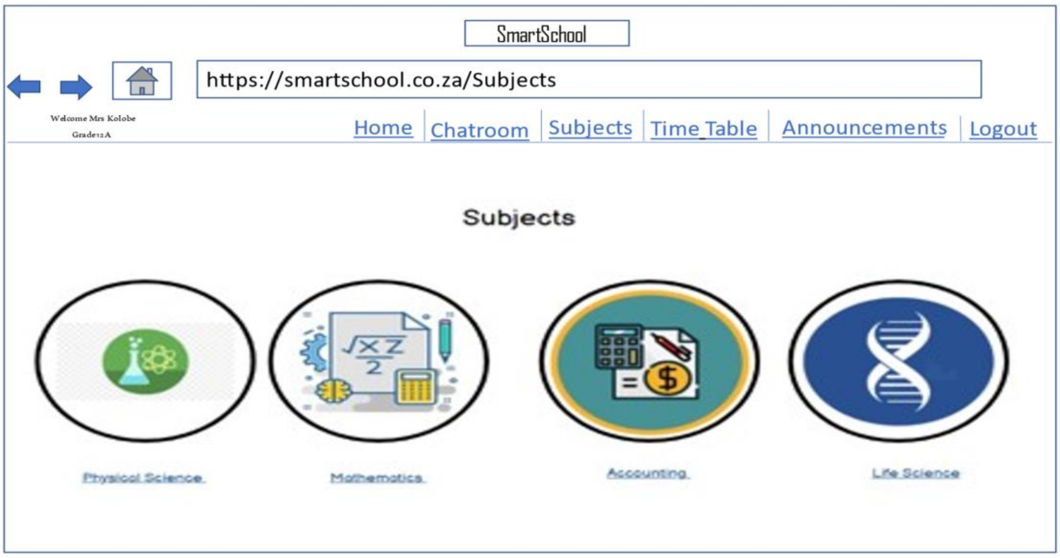

**a) Login Screen**

This is the SmartSchool login screen for teachers and learners. Both learners and teachers can use their username and password to log in to the solution.



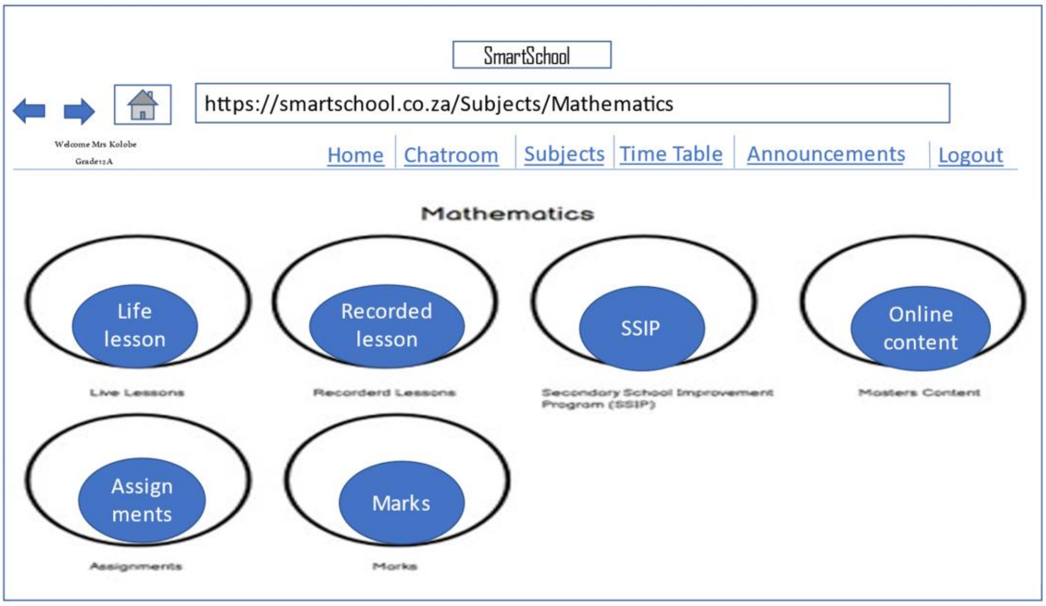
**b) Home Page**

Upon successfully logging into the system, the learner will land on the home page, where he or she will see the live lessons. A learner will have the option to click on the 'join' live lesson by clicking the join button or click on cancel to cancel. On the right hand side, the learner will be able to see all the announcements for both leaners and teachers.



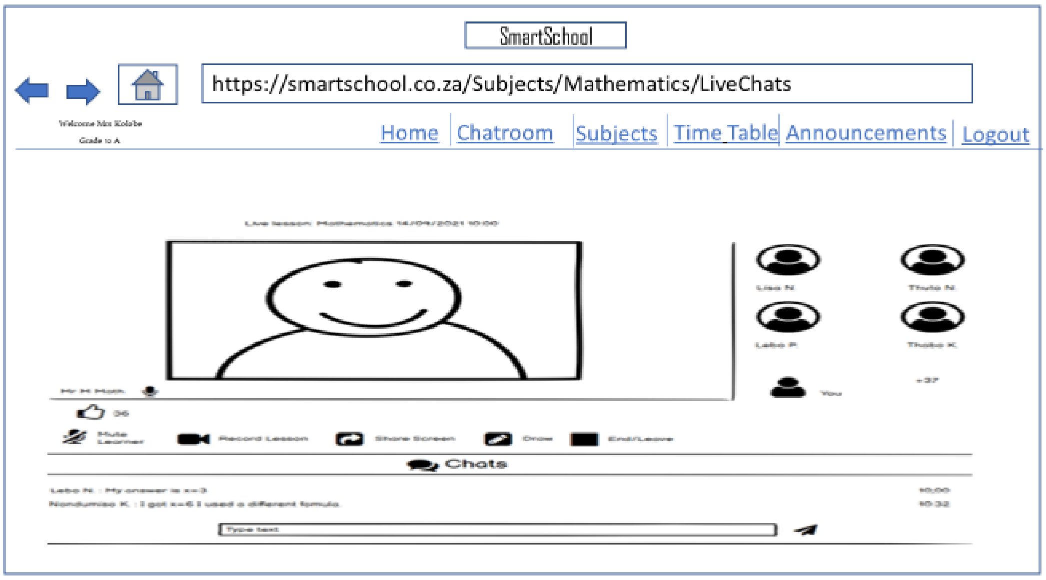

**c) Subjects**

The learner will need to select the subject. After selecting the subject they will be able to access most of the features that are specific to that subject. Here the learner will be able to see all the subjects they registered for.



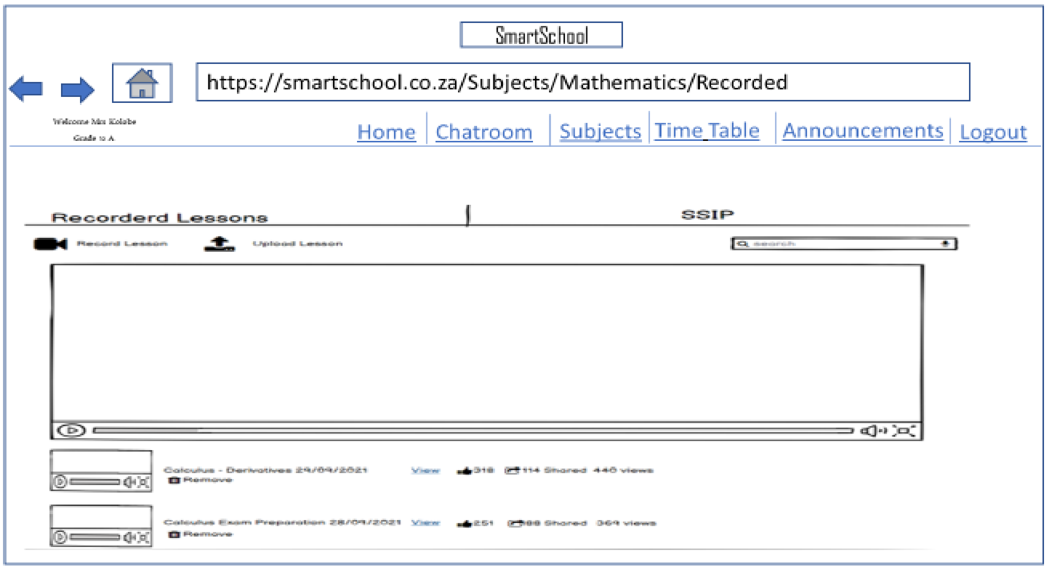

**d) SmartSchool Features**

After selecting the subject, the learner will see all features that they have access to under the subject "Mathematics". The learner can select a feature that they would like to use from the options that are available.




**e) Individualized Learner Support Activities**

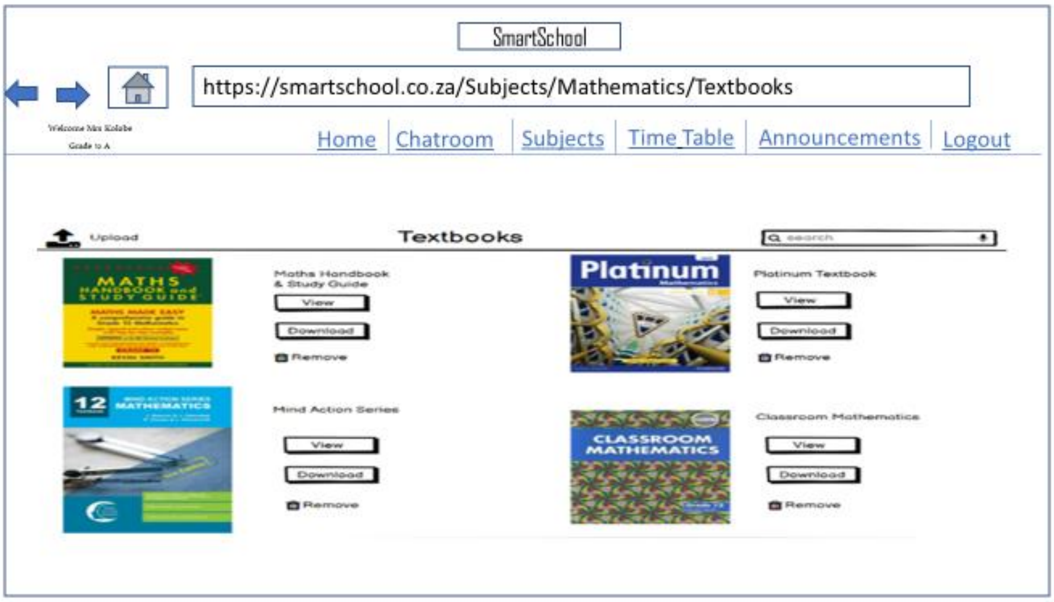
As the teacher will be able to create a list of low ability learners, he or she can upload support learner activities that are tailor made for the learner's learning ability and style. The teacher will also be able to view the learners that have submitted their individualised support activity responses. The solution will enable the teacher to view the marked individualised support learner activities on the marked activities tab, and the number of learners who have either joined or watched the recorded sessions as the monitoring tool.




### f) Recorded lessons

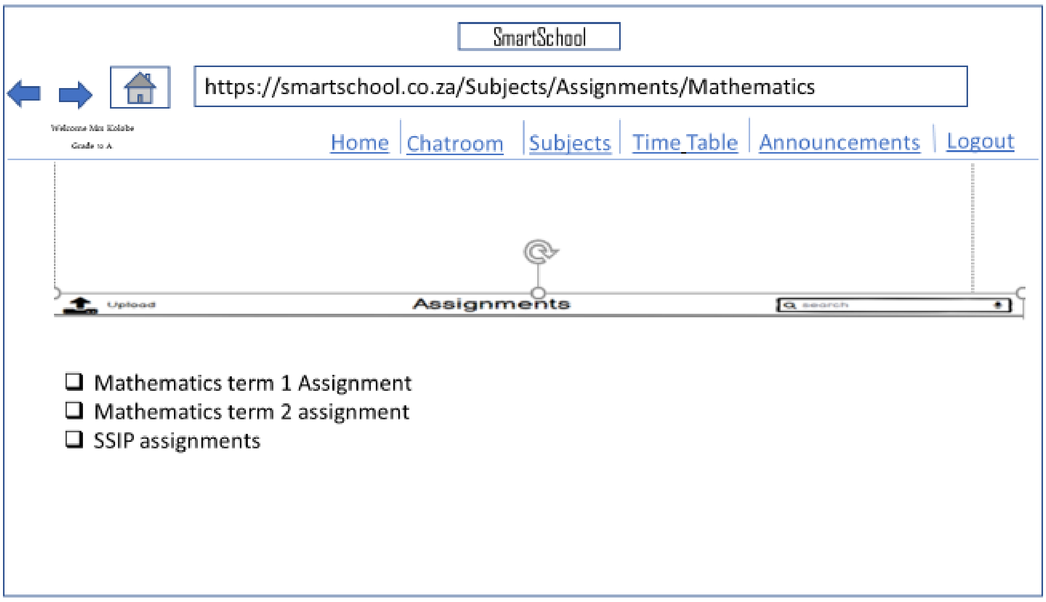
The solution offers an opportunity for teachers to upload recorded lessons for the learner's convenience. This could be extra classes, SSIP lessons and the learners may be able to watch at any given time. This ensures that no learner is left behind and learning continues beyond stated times.

Teachers can record lessons to enable learners to listen to lessons and better understand the content. The recorded lessons also show the number of learners that viewed the lesson, it also suggests the video with the highest views and likes, which is relevant to the learner's topic. The lessons can be downloaded by both the learners and teachers at any school.



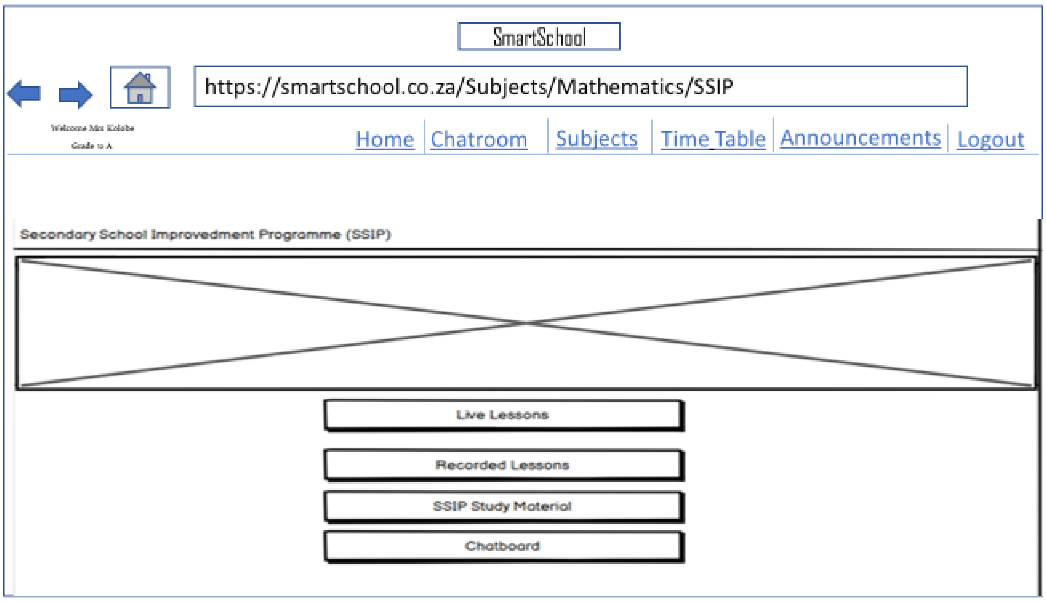

**g) Resources**

The solution offers a variety of resource banks. The E- text books used by the Grade 12, departmental resource portals and other resources available online.




**h) Activities and Assignments**

A teacher is able to upload various informal practise activities which learners can access remotely, and it also offers access for learners to work out the solutions and send the responses back to the teacher.

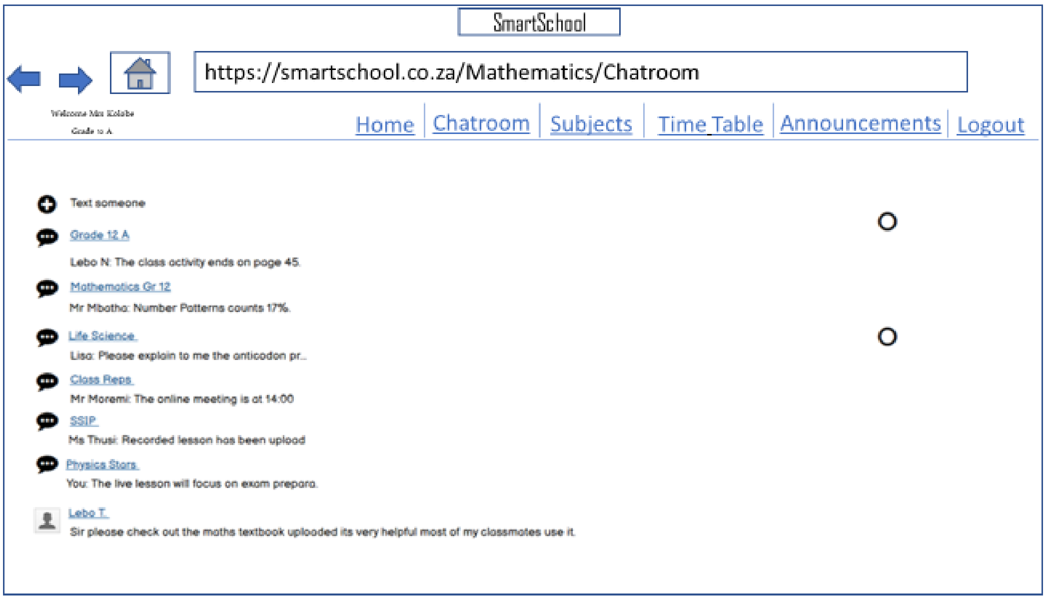



**i) SSIP Resources**

The solution brings both face-to-face and Web interactions under one solution. Both camp and SSIP lessons are recorded and uploaded into the portal for easy access for learners who are either in the cluster or in a different cluster. This connection allows interaction and access to resources and support lessons of a larger peer learning group.

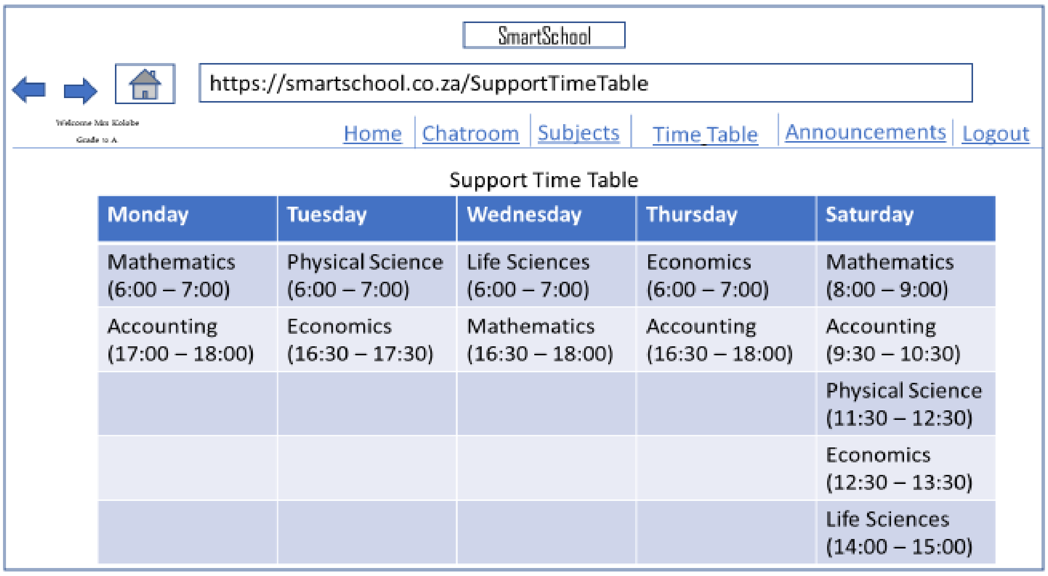
**j) Announcement**

The solution allows teachers to post announcements, reminders of upcoming activities such as tests and available live sessions.




**k) Live Lessons**

The solution enables the teacher to join and create live lessons and the teacher will be able teach the leaners virtually. The leaners will be able to share their work by using the work page and to share their answers on the live lesson using the chat feature. The teacher has control features like the ability to mute leaners and to invite other teachers to join the live session.




| Monday | Tuesday | Wednesday | Thursday | Saturday |
|---|---|---|---|---|
| Mathematics (6:00 – 7:00) | Physical Science (6:00 – 7:00) | Life Sciences (6:00 – 7:00) | Economics (6:00 – 7:00) | Mathematics (8:00 – 9:00) |
| Accounting (17:00 – 18:00) | Economics (16:30 – 17:30) | Mathematics (16:30 – 18:00) | Accounting (16:30 – 18:00) | Accounting (9:30 – 10:30) |
| | | | | Physical Science (11:30 – 12:30) |
| | | | | Economics (12:30 – 13:30) |
| | | | | Life Sciences (14:00 – 15:00) |

**I) Timetable**

The support timetable will enable the learners to draw up and manage their own schedules and be a part of each supportive session for any subject without clashes.

## 6.3 CONCLUSION

The above solution is aimed at supporting progressed learners through the use of instructional technology, face-to-face traditional support activities and connectivism. Teachers are connected to learners and fellow teachers to share learning practices. ICT instructional resources are brought together into easy access for a learner, and this is a uniform way in which connections are made and monitored.

The framework investigated the respondents' common practices and consolidated them together into a single tool which could be accessible and utilised by both learners and participants. This model can assist both learners and teachers who prefer digital instructional technologies and those teachers and learners who prefer face-to-face traditional support strategies. To conclude, the following chapter of conclusions and recommendations draws the conclusion that progression policy does exist in a number of countries as cited in literature, although termed differently, and there are a number of strategies in place globally to improve Mathematics attainment including South Africa as findings indicate. ICT instructional technologies have been widely acknowledged and implemented as one of the support or teaching pedagogies cited as best practice and the designed frame has investigated the link between supporting progressed learners with ICT instructional technologies and linking it with non-ICT instructional technologies in the connectivism ideology of learning.

# CHAPTER 7: RECOMMENDATIONS AND CONCLUSIONS

## 7.1 INTRODUCTION

This chapter gives recommendations of the findings as detailed in the previous chapters and will provide concluding remarks. Looking into the study findings, it has been ascertained that the use of connectivism as a support strategy using ICTs is effective. There are however various types of digital networks applied in various schools, and their applications and their effectiveness are determined by the availability of resources in each school.

It has further been established that although there is a legal framework which instructs educators to progress learners to the next grade (DBE 2011 and 2016), there is no proper guide on how such learners should be supported. Certain schools still prefer the traditional support strategies of face-to-face morning, afternoon and Saturday lessons.

The recommendations will give light on how best both the Department of Education and the schools can strengthen these strategies and consolidate all strategies into a single working tool.

## 7.2 SUMMARY

As indicated in the South African School Act cited in DBE (1996), for a learner to be promoted to the next grade, there are guiding principles that guide the movement. A learner must meet the requirements in order to be promoted as tabled in Chapter 1 of this study. If a learner does not meet the pass requirements as prescribed by the CAPS policy (DBE, 2011), they can be progressed due to age and the number of years spent in the phase. A learner can further be progressed due to mark adjustment (DBE, 2015) and Mathematics condonation (DBE, 2017 & 2020).

There are various suggestions and strategies recommended to assist learners who are termed progressed learners. These strategies vary from school to school depending on the school resources, the number of progressed learners and types of teachers teaching them. Mathematics condonation has seen a rise in the number of learners who are progressed but have failed Mathematics in Grade 11, putting extra pressure on teachers to ensure that these learners pass Grade 12. The university entry requirements do not consider the concept of Mathematics condonation. A Grade 12 pass in Mathematics is still a requirement for Mathematics and Science entry courses.

Through several scholarly articles reviewed under the literature review, one can establish that Mathematics achievement is a challenge worldwide. Looking at the TIMMS report, as outlined by Reddy et al. (2016), Mathematics achievement is quite low in several countries, South Africa included. A number of countries such as the UK, USA, Japan and Canada have invested a lot of time and resources to come up with different strategies to improve Mathematics achievement, such as the introduction of learner-centred pedagogies in delivering teaching and learning. These include the use of ICT both in and out of the classroom. This study has further established the importance of Mathematics not only for university entry requirements but also as a determinant for future employment.

Another focus of this study was the South African Mathematics performance. The literature established that there is a serious Mathematics challenge in South Africa, and it does not only start in the senior grades but from the foundation phase. According to Sinyosi (2015), the quality of primary school Mathematics achievement is low. This is further seen in the TIMMS and SACMEQ 3 reports where South Africa achieved the lowest in both Grade 5 and 9 Mathematics and Science performance. Several reasons were cited for the low performance in Grade 12 Mathematics achievement and one of them, as cited by Zimasa (2016) while interviewing teachers, was the progression of learners to the next grade and teaching a mixed class of both high ability learners and progressed learners.

This study examined, in detail, the progression policy and the teaching of low ability learners in Mathematics. As indicated, most learners who are progressed have received Mathematics condonation (DBE, 2020). This implies that teachers must work extra hard to not only teach, but to support these learners to be on par with their classmates. Othman, et al. (2016) suggests that it is vital to separate progressed learners from high ability learners in order to be able to give them the necessary support and time required. Unfortunately, this strategy does not apply in the South African schooling system due to human resources and infrastructural challenges. This then leaves teachers with the task to design lessons that both accommodate high ability learners and progressed learners.

This study also examined the application of connectivism as a strategy using ICT instructional technologies to support progressed leaners; the benefits and challenges. The study further explained the background and legal framework guiding progression policy in South Africa. The study further investigated other forms of support offered by teachers different from ICT instructional technologies. The findings from these participants indicated limited impact in terms of progressed learners' performance as compared to learners who are using ICT instructional technologies as support platforms.

Looking at all the respondents' views and analysing of documents, the following have been discovered in terms of using ICT instructional technologies in a connectivist classroom setting. These schools apply what Bahubali (2020) asserts to be blended learning. This is described as an educational approach that applies both digital online material with traditional type classroom teaching methods (Bahubali, 2020). This type of learning encompasses traditional methods of teaching with e-learning methods that extend beyond the classroom.

These learners use gamification, concrete representations, manipulations and repetitions as a way of studying Mathematics. Knowledge creation does not only rely on the teacher as a source, but knowledge is created through various connections some of which are non-human. The type of learning adopted by these participants is in line with Siemens (2005) school of connectivism.

In their argument, according to Das (2019) this type of learning offers the following benefits that are similar to this study's findings:

- offers a more learner-centred learning.
- enhances learner to learner collaboration.
- gives multiple technologies exposure and opportunities.
- increases interest and participation among learners.
- offers learners extra resources to aid learning.

Bahubali (2020) further shares the same findings as this study by indicating the following offered by using ICT instructional technologies:

- ICT instructional technologies enhance simple teaching. The use of graphics, pictures and videos improve knowledge transfer and acquisition.
- It involves the use of real objects, which can be seen or heard. This is a great advantage to learning, especially for low ability learners. An example is simulations.
- ICT instructional technologies encourage easy understanding of concepts and better ways of communication.
- It further makes learning fun and improves learner attainment.

Alkamel et al. (2018) further indicate the availability of multiple information sources that act as support strategies for low ability learners. The interlinking of traditional and new ICT instructional technology approaches should not be isolated, as both support teaching and learning (Alkamel et al., 2018). Bahubali (2020) further indicates that the use of ICT improves motivation towards schooling; this was described by the participants in terms of school attendance and subject participation.

According to Bouchey et al. (2021) blended learning using multimodal devices encourages learners' voices in the process of learning and this learning shapes content, ways in which learners respond as well as how instruction is delivered. Bezemer and Kress (2016) also found that blended learning encourages deep learning because learners are offered an opportunity to take part in various cognitive problem-solving activities that are aligned to their curriculum. Content is delivered in multiple modes like visuals, text, video links and PowerPoint presentations (Bouchey et al., 2021).

## 7.3 LIMITATIONS OF THIS STUDY

Dow (2020) argues that qualitative research depends highly on the researcher's findings, which are the participants' perspectives and views, and the final deciding factors are at the researcher's discretion. The findings of this study cannot be generalized as representing a broader population of South African schools using connectivism in ICTs. This study was a research project in fulfilment of a PhD dissertation. Its main objective was to investigate the use of connectivism as a support strategy for progressed learners in Mathematics using ICT instructional technologies.

The sample for this study was limited to sixteen Grade 12 teachers teaching Mathematics in Circuit 4 Ekurhuleni North district. This then implies that the sample was not a full representation of what exists in all Gauteng schools, especially as the education classification is very different and the resource allocations are not the same. Therefore, what may be the case for township schools may not necessarily be the case for privileged schools classified as ex-model C schools, or private schools that are highly resourced with learners from affluent families.

Some of the interviews were done telephonically due to the restrictions of Covid-19. Even though the researcher could access several people in very far areas using telephonic interviews and Google forms. Samanta (2020) asserts the following disadvantages of telephonic interviews:

- Social cues are reduced.
- The interviewer is unable to see the participant, hence body language is not easily detected, although intonation can still be detected and the environment in which the participant is in does contribute to the researcher's analysis.

Another limitation of this study was that not all schools used tracking tools to monitor and analyse progressed learners' performance. Only three tracking tools and their findings were reviewed for cohort participants. Although all participants agreed that their results indicated an upward trend in performance, it may not be the case in all the schools that participated.

## 7.4 CONTRIBUTIONS OF THIS STUDY

This study has contributed as a source of knowledge and a point of reference for future scholars. The study has further contributed to the literature, especially in South Africa where the progression policy is still in its inception stage. As much as progression policy is still a new concept in South Africa, literature has established that this practice has been taking place in other countries, and scholars who are interested in furthering this discussion, can use this study as a source of reference or comparison of what South Africa is doing compared to the rest of the world.

Connectivism theory has never been used in the literature on progression theory; this makes this study very useful in terms of its contribution to the literature. Moreover, because the country has not yet developed a blueprint of support strategies for progressed learners, this study will also act as a reference for the Department of Education in the rollout of strategies to support progressed learners, especially in Grade 12 using ICT instructional technology frameworks and guided by connectivism ideology.

One of the objectives of this study was to design a framework which guides the implementation of support strategies using both ICT instructional technologies and non-ICT instructional technologies. This study came up with a new framework, which could be developed as a solution model in addressing the deficit observed with the lack of, or unavailability of uniformed strategies, which could accommodate both highly resourced and less resourced learning communities. Both the traditional support strategies, common among participants and ICT instructional technologies advocated by participants are consolidated into a single functional tool, which could be an answer to the South African education in the process of implementing progression policy within its schools.

## 7.5 RECOMMENDATIONS

### 7.5.1 THE EFFECTIVENESS OF USING CONNECTIVISM IN SUPPORTING PROGRESSED LEARNERS USING ICTS

The challenges of the progression policy have been established in this study. Schools are required to move learners to the next grade regardless of their Mathematics achievement. The traditional support strategies are yielding less or no impact towards learner performance. It is therefore recommended that ICT instructional technologies should be applied in a connectivism classroom setting. According to Kropf (2013), connectivism is a theory that allows teaching and learning to be effective in the digital age. Its effectiveness has been established by Marhan (2006) and It improves the quality of teaching and learning (Al-Shehri, 2011).

Learning is more learner-centred and is a continuous process in which learners participate easily, anywhere and at anytime. Both literature and the participants' views are similar, and the researcher therefore recommends an application of ICT instructional technologies, together with other non-ICT instructional technologies such as SSIP, be used concurrently in connectivism ideology to improve the quality of teaching which will ultimately benefit all learners, both promoted and progressed. It is therefore recommended that schools should prioritize the application of the set framework of connectivism as a strategy to support progressed learners.

### 7.5.2 FORMS OF NETWORKS CREATED AND THEIR EFFECTIVENESS

Connectivism is driven by the ability to form functional networks and links which facilitate teaching and learning (Siemens, 2012). Both the literature and the teachers' views on the importance of networks are established in this study. It is therefore recommended that stronger networks which are easy to monitor should be developed and facilitated by teachers in order to control the flow of discussions and encourage low ability learners to participate in these networks. It is further recommended that policy makers should include connectivism as a formal strategy to support progressed learners and enable schools with the resources to make the implementation thereof easy.

### 7.5.3 THE IMPACT OF CONNECTIVISM IN SUPPORTING PROGRESSED LEARNERS

The flow of information has changed over the years, unlike previously where materials were only posted for the learner's benefit. New applications allow a virtual learning environment whereby participants also take part in knowledge formation and distribution. These networks are easy to change, user friendly and some do not necessarily require an educator to guide the discussions (Poore, 2015).

The findings have indicated the positive results of using connectivism to support progressed learners as opposed to the traditional way of supporting learners through the use of extra lessons. As much as this occurs on a smaller scale, due to its positive impact especially on the learners' performance, it is recommended that connectivism should not only be a strategy employed to support low ability learners, but a new teaching method which could be adopted to ensure that learning continues even beyond the classroom with multiple connections created.

As Siemens (2005) advocates, connectivism allows learners a platform to choose how and what knowledge they want to create, and connectivist scholars such as Downes (2006) believe that connectivism closes the gap which was left by other theorists to allow teaching and learning not only between humans, but also among non-human objects such as computers. The framework designed in the previous chapter offers time flexibility, can accommodate a large connection, and resources are at the learners' disposal at all times.

If correctly administered, social networks can improve the learner's intellectual ability (Poore, 2015). However, one blog created by a teacher does not guarantee an automatic improvement. Learners must be challenged to be able to be critical thinkers and to encourage higher-order thinking and problem-solving. Various material sources need to be aligned with the curriculum, synthesized and analysed using various viewpoints and packaged together in a single framework for learners' accessibility.

### 7.5.4 LEARNER PERFORMANCE TRACKING

Learners' performance tracking tools should be used to assess if there is progress being made while supporting these learners. Looking at what exists in the sixteen participants' schools, one can recommend that in both formal and informal activities, learners' performance should be tracked and analysed to ascertain if the strategies are yielding positive results and give recommendations for further improvement and development. The framework model designed in the previous chapter offers a link to learner performance monitoring as well as participation monitoring. The framework offers proper monitoring of learner engagement, such as signing in credentials that may work as an attendance register as well as the view tab which indicates how many learners have viewed a recorded lesson.

This will enable an educator to engage learners who do not participate, or who hardly participate.

### 7.5.5 RESOURCES

This study has established that not all the schools or learners participate equally in the networks. The schools with higher participation have enough resources to assist their learners, such as access to connectivity and laptops while schools with low participation have indicated the lack of resources, such as ICT and connectivity. This study therefore recommends that the Department of Education prioritize the use of ICTs, especially for Grade 12 learners as its importance and effectiveness has been established in this study.

### 7.5.6 CAPS POLICY

There are no common strategies teachers are expected to use. The Department of Education only offers standard resources and annual teaching plans which are compacted with a lot of information. This becomes a challenge in syllabi completion taking into consideration the pace of low ability learners. It is therefore recommended that the Department refine the curriculum to take into consideration that Grade 12 learners only have three terms to study, and progressed learners take time to comprehend concepts, and their pace and quantity of work given may place them at a disadvantage.

### 7.5.7 GENERAL RECOMMENDATIONS

- The use of the SmartSchool application or similar developed models can act as a common tool applicable as a support strategy to assist progressed learners.
- Teachers need to encourage more learners to be part of networks and fully formalize their existence.
- Schools need to be fully resourced with technological devices that will support teaching and learning.
- The Department of Education should prioritize ICT tools in schools to enable teachers and learners to function.
- Stronger networks need to be established which will support teaching and learning, and teachers need to continuously monitor the type of content learners share. There should be constant tracking of learner performance, even for informal activities, to ascertain learner progress.

### 7.5.8 RECOMMENDATIONS FOR FUTURE RESEARCH

The application of connectivism has been echoed as impactful both through literature and participation in South Africa and globally, although the scale of application is still low. It is recommended that this way to support progressed learners will be further explored in the South African context, as progression policy does influence the South African education system.

A broader sample of both urban and rural schools still needs to be explored. There is also a further need to do this study using the foundation phase and tracking their performance over a couple of years using different subjects in different grades.

## 7.6 CONCLUSIONS

The aim of this study was to investigate the use of connectivism as a support strategy for progressed Grade 12 Mathematics learners using ICT instructional technologies. As outlined in the earlier chapters there is a concern pertaining to the progression policy affecting learner pass rate (Nomahlubi, 2018; Zimasa, 2016). The main reason the researcher undertook this study was that there has been no study that has focused on the use of connectivism specifically aimed at supporting progressed Mathematics learners, especially in township schools, using ICTs. The study's relevance was further amplified through remote learning which resulted when schools had to close because of Covid-19.

This research was a qualitative study that collected data using in-depth interviews that were open-ended in nature and questionnaires and document analysis. Sixteen participants who are Mathematics teachers, who were purposefully and conveniently selected from five secondary schools, participated. As indicated in Chapter 5, the research established that ICT instructional technologies in connectivism enables the support of progressed learners. The benefits include improved progressed learners' performance as seen in their Term 3 results, high learner participation which is indicated by the number of learners participating per class, teaching and learning which are learner-centred and self-discovery of information which allows collaboration and cooperative learning.

There was clear evidence from both policy and lesson plans that the progression policy exists, and it rests upon each school to support its learners in the best possible way to put them on par with the rest of their classmates. The Matric examination does not take into account that some learners were promoted meeting the pass requirements, while others were progressed having failed subjects like Mathematics. The study further recommended the need for further resourcing of schools and a review of the CAPS policy to accommodate low ability learners.

The researcher concludes that connectivism is one of the most effective strategies when used with ICT instructional technologies to support progressed learners. It allows for learner autonomy; it improves learner participation and performance and most importantly, teaching and learning become continuous. The ability to connect to various sources of data through new technologies keeps learning up to date and relevant (Yodsaneha & Sopeerak, 2013), and progressed learners are given a choice to study whichever way they prefer to learn.

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UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

# APPENDIX A: GDE APPROVAL LETTER

GAUTENG PROVINCE

REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

**GDE RESEARCH APPROVAL LETTER**

| | |
|---|---|
| **Date:** | **22 September 2020** |
| **Validity of Research Approval:** | **04 February 2020 - 30 September 2020**<br>**2019/619** |
| **Name of Researcher:** | **Kolobe LV** |
| **Address of Researcher:** | **18 Glenvalley** |
| | **Baker Road** |
| | **Sebenza /Edenvale** |
| **Telephone Number:** | **082 600 7780** |
| **Email address:** | **Lineokolobe11@gmail.com** |
| **Research Topic:** | **Connectivism as a strategy to support progressed Mathematics learners through Information Communication & Technology.** |
| **Type of qualification** | **PHD** |
| **Number and type of schools:** | **5 Secondary Schools** |
| **District/s/HO** | **Ekurhuleni North** |

***Re: Approval in Respect of Request to Conduct Research***

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the school (both Principal and SGB) and the District/Head Office Senior Manager confirmation and permission has been granted for the research to be conducted.

Kind regards

The following conditions apply to GDE research. The researcher may proceed with the above study subject with the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *Letter that would indicate that the said researcher has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. ***Because of COVID 19 pandemic researchers can ONLY collect data online, telephonically/y or may make arrangements for Zoom with the school Principal. Requests for such arrangements should be submitted to the GDE Education Research and Knowledge Management directorate. The approval letter will then indicate the type of arrangements that have been made with the school.***
4. ***The Researchers are advised to make arrangements with the schools via Fax, email or telephonically with the Principal.***
5. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher's have been granted permission from the Gauteng Department of Education to conduct the research study.*
6. *A letter I document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
7. *The Researcher will make every effort obtain the goodwill and co-operation of all the GOE officials, principals. and chairpersons of the SGBs, teachers and learners involved. Persons whooffer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalized in any way.*
8. *Research may only be conducted after school hours so that the normal school programme is notinterrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher's may carry out their research at the sites that they manage.*
9. *Research may only commence from the second **week** of February and must be concluded beforethe beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
10. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GOE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
11. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
12. *The researcher is responsible for supplying and utilising his/her own research resources, such asstationery, photocopies, transport taxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
13. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of eachof these individuals and/or organizations.*
14. *On completion of the study the researchers must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
15. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GOE officials and the schools concerned.*
16. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looksforward to examining the findings of your research study.

Kind regards

Mr· Wani Mukatuni

Acting' CES: Education Research and Knowledge Management DATE:

22/09/2020

*Making education a societal priority*

Office of the Director: Education Research and Knowledge Management

7th Floor, 17 Simmonds Street, Johannesburg, 2001Tel: (011) 355 0488

## APPENDIX B: GDE REQUEST FOR PERMISSION LETTER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

Gauteng Department of Basic Education

To: The Director

Research unit

Johannesburg

Dear Sir/Madam,

**RE: REQUEST TO THE GDE FOR SECONDARY SCHOOLS TO PARTICIPATE IN A TELEPHONIC INTERVIEW AND DOCUMENT ANALYSIS FOR A RESEARCH PROJECT:**

**Connectivism as a strategy to support progressed Mathematics learners through information communication & technology**

I am Lineo Kolobe, currently enrolled for a PhD degree at the University of Pretoria under the supervision of Dr. Maryke Mihai. The title of my approved research study is: **"***Connectivism as a strategy to support progressed Mathematics learners through Information, Communication & technology."*

The aim of the study is to investigate how educators use connectivism in ICT to support progressed learners in Mathematics. To obtain data for this study, the interview and questionnaire method will be used with educators, as well as lesson plans and an analysis of their policies and tracking tools for learner performance.

The telephonic interview with each educator will take approximately 30 to 45 minutes outside of contact time. Secondly, an electronic goggle form will be sent to educators and this will take about 30 minutes out of the school contact to fill in.

I have included here for your information a schedule of interview questions and the questionnaire.

I hereby request your permission to allow educators from the identified schools in your department to:

1. participate in the interview.
2. participate in a short questionnaire

3. share lesson plans, learner performance tracking tools.
4. share some networks learners have created.

All participation is completely voluntary. No harm or injury will come to the educators during the interview. Please note that the decision for educators to participate is completely voluntary and this will not affect their livelihood. No results attained in the interview will be used for assessment purposes. The educators may request to leave the interview at any time without any explanation or consequences.

As part of the data collection, I will be using an audio recorder from a telephone application to capture the interviews for research purposes. The purpose of the audio recorder is to capture and transcribe the data accurately. All information obtained during the research study will be treated confidentially. My supervisor and I will have access to the data. The names of educators, principal or school will not be mentioned during any phase of the study. Furthermore, pseudonyms will be used to avoid identification of the educator and school.

At the end of the study, I will provide the GDE with a copy of the dissertation containing both the findings of the study and recommendations. In addition, I would like to request your permission to use all data, confidentially and anonymously, for further research purposes, as the data sets will become the intellectual property of the University of Pretoria. Further research may include secondary data analysis and use of the data for teaching purposes. The confidentiality and privacy applicable to this study will be binding on future research studies.

The information gained during the study will be treated with confidentially. Neither the University of Pretoria nor the Department of Education will have access to the raw data obtained from the interviews. At no time will either the individual or school be mentioned by name or indeed be allowed to be identified by any manner or means whatsoever in the thesis.

Thanking you in advance,

LSereetsi-Kolobe..

| | |
|---|---|
| Mrs L.V Kolobe | Dr. M. Mihai |
| Student Researcher | Supervisor |
| University of Pretoria | University of Pretoria |
| Lineokolobe11@gmail.com | maryke.mihai@up.ac.za |
| 082 600 7780 | 082 430 2928 |

# APPENDIX C: GDE CONSENT LETTER

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

**LETTER OF CONSENT TO GDE**

**FOR VOLUNTARY SCHOOL PARTICIPATION IN THE RESEARCH PROJECT ENTITLED:**

Connectivism as a strategy to support progressed mathematics learners through technology

I, _______________________________________________, (Full name) the representative of the GDE

Please tick the appropriate block

Give consent ☐

Do not give consent ☐

to allow selected schools under the jurisdiction of the GDE to participate in the above-mentioned study introduced and explained to me by Mrs Lineo Kolobe, currently a student enrolled for a PhD degree at the University of Pretoria.

I further declare that I understand, as explained to me by the researcher, the aim, scope, and purpose of collecting information proposed by the researcher, as well as how the researcher will attempt to ensure the confidentiality and integrity of the information she collects.

__________________________________________ ____________________________

Full name Signature

_____________________

Date GDE stamp

# APPENDIX D: INTERVIEW SCHEDULE

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

**The proposed interview questions**

Kindly answer the following biographic questions

1. Age
2. Gender
3. Number of years in service

Answer the following questions as best as you possibly can:

1. How do you go about using connectivism in integrating ICT in your lessons to support progressed learners in Mathematics?
2. When did you start teaching progressed learners using the connectivism model in ICT?
3. How do you feel about teaching progressed learners with ICT using the connectivism theory?
4. What type of ICT tools do you prefer in supporting progressed learners in Mathematics and why?
5. How effective are the networks formed by progressed learners through learning with ICT?
6. In which part of the lessons or content do you think it is appropriate to use ICT to support progressed learners and why?
7. Does the connectivism networks extend beyond the classroom and what are the ICT resources progressed learners use beyond the classroom?
8. How often do you integrate ICT in your lesson planning for progressed learners and why do you choose to do so?
9. How do you think connectivism used within ICT contributes towards content delivery in teaching progressed learners?
10. How are you creating content in Maths suitable for progressed learners using ICT network tools?

11. What is the impact of connectivism and ICT support strategies on progressed learners' performance in Maths?
12. What are some of the perceived benefits of using connectivism and ICT in your pedagogy in teaching Mathematics for progressed learners?
13. How do the progressed learners react towards learning using connectivism and ICT?
14. In your opinion, can you say ICT has assisted you to support progressed learners? How?
15. Has the introduction of connectivism in ICT made support for progressed learners easy? How?
16. How does ICT and connectivism affect the classroom atmosphere and learner discipline?
17. What challenges are you facing in integrating connectivism and ICT into teaching Mathematics for progressed learners?
18. How has using connectivism and ICT to deliver content knowledge affected midterm pass rates for progressed learners?
19. What is the impact of using connectivism with ICT on progressed learners' achievement?
20. How do the networks enhance by ICT support learners with homework?
21. What is the link between the current curriculum and the available connectivism and ICT strategies at your school?

# APPENDIX E: INTERVIEW RESPONSES

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

**BIOGRAPHICAL INFORMATION**

| NAME | AGE | GENDER | POSITION | NO OF YEARS IN SERVICE | QUALIFICATION | SUBJECTS | NATURE OF APPOINTMENT |
|---|---|---|---|---|---|---|---|
| PARTICIPANT A | 33 | FEMALE | PL 1 TEACHERS | 7 | BED | MATHEMATICS & MATHS LITERACY | PERMANANET |

| No. | Questions | Candidate A |
|---|---|---|
| 1 | How do you go about using connectivism in integrating ICT in your lessons to support progressed learners in Mathematics? | As much as I do not know the concept connectivism I assume from your explanation it is studying with our small network groups. we have WhatsApp groups, Facebook, telegrams at times we use zoom meetings. Our Facebook platform has a number of followers who share different methodologies and solutions when addressing concepts, you find not just my school but learners from other schools. We have recently introduced Microsoft teams meetings with my PLC where we share which methods learners understand better. Another thing I have introduced my learners to a various Facebook groups created by my former classmates at Wits who are Facebook tutors, and their support sessions are free of charge, we have shared and exchanged ideas in our page and post various links of solutions. With the lockdown, our digital communication improved as we created a number of communication platforms such as Share it, WhatsApp, Zoom and Facebook here at school.<br>We use technology both in and out of the classroom. These offers manipulatives and demonstrations for difficult concepts.<br>I use an app like Geogebra to analytical geometry. I have shared these on WhatsApp and Wits Maths students' group. Certain apps such as Geogebra makes teaching Mathematics easier because it concretely gives demonstrations. The Apps use repetitions and digital games, and we get them online and they offer continuous practice. |
| 2 | When did you start teaching progressed learners using the connectivism model in ICT? | We are not a full ICT school, I started introducing my learners to learning with technology three years ago when I moved to this school. We have interactive white boards which we link to teach and our school's matric learners are also given tablets but there is a huge logistical nightmare in terms of distribution and retrieval. Learners claim that they get stolen and getting them through retrieval at the end of the year is simply impossible |

| | | |
|---|---|---|
| 3 | How do you feel about teaching progressed learners with ICT using the connectivism theory? | With the lockdown, our digital communication improved as we created a number of communication platforms such as Share it, WhatsApp, Zoom and Facebook at our school.<br>It is really functional especially our WhatsApp group because I am quite in touch with my learners. One thing I noted was that one small group of WhatsApp where I supported my learners some of which were not only from our school, this is to show how far connected these platforms are, they are really useful and not only for progressed learners but all our Maths learners. Communication is easy and effective, certain learners take the leadership roles to maintain these links and ensure that the flow of information is properly managed . |
| 4 | What type of ICT tools do you prefer in supporting progressed learners in Mathematics and why? | With the limited resources we make do with what ever is at our disposal. Learners follow certain Facebook groups which are Mathematics aligned.<br>We use laptops which are in our labs, due to the limited number of these laptops in other situations learners are expected to share as we have bigger numbers. Our school's matric learners are also given tablets but there is a huge logistical nightmare in terms of distributions and retrieval. There are also interactive white Boards (IWB's) in each class loaded with E- curriculum. While we struggle with the distribution our learners are encouraged to use cell phones and tablets to create small study groups. We use zoom meetings at times |
| 5 | How effective are the networks formed by progressed learners through learning with ICT? | I can say at most 80 %, of my learners I would say are very active in our groups. There are some who have challenges but quiet a number of them participate. The groups function mostly at home or after classes, so learners stay longer at school for connectivity while some study at the comfort of their homes. The exciting part was we saw our learners even competing with learners from other schools using these platforms. |
| 6 | In which part of the lessons or content do you think it is appropriate to use ICT to support progressed learners and why? | I sent links to learners for research prior to as an introduction and to test prior knowledge. This then kick starts classroom discussion as learners share their models or video links demonstrating different methods which could be applied in solving certain problems. Our learning is a bit learner controlled and participation is quiet good. We use these platforms further to send homework and general support activities for daily practice. |
| 7 | Does the connectivism networks extend beyond the classroom and what are the ICT resources progressed learners use beyond the classroom? | Yes it does, I sent links of content to my learners this then kick starts classroom discussions as learners share their models or video links demonstrating different methods which could be applied in solving a certain problem,. Learning takes place even outside the classroom and what we do is called continuous classroom which extends to home, it is no longer the traditional homework. It encourages knowledge between them and myself. The gap between the school vs home culture of learning is reduced. |
| **8** | How often do you integrate ICT in your lesson planning for progressed learners and why do you choose to do so? | I use technology to teach, to give support and for demonstrations as I have already demonstrated. It is mostly daily depending on the topic, it could be in class or out of class. I used technology to teach, to give support and for demonstrations as I have already demonstrated. It is mostly daily depending on the topic, it could be in class or out of class. |

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| 9 | How do you think connectivism used within ICT contributes towards content delivery in teaching progressed learners? | These learning groups assist a lot. There is a continuous interaction through the use of social media platforms which enhances teaching and learning. WhatsApp is the most popular and effective at our school and it acts as an instant messenger. The video links sent via WhatsApp groups or we share in class with Share it use concrete representation making Mathematics more abstract. Like Geogebra we do demonstrations, we use game like Apps and learners can continue to practice while at home outside school bounds. I will make a small demo with this App. This line drawn through the centre of a circle to bisect the chord is perpendicular the chord. What Geogebra demonstrates is the line AF will bisect the chord line CD as illustrated. A circle with centre A, the chord was CD and AF bisects CD that is we have FD which will be equal to FC. There are also other apps such as Jamboard and Desmos which we use to teach. (to share links) |
| 10 | How are you creating content in Maths suitable for progressed learners using ICT network tools? | Learners are exposed to new and relevant information at all times. The Geogebra app, the YouTube videos and other online material is very helpful to simplify and explain concepts. I just google a topic and there are number of tutorials and we select from there. I just assist aligning them to our curriculum CAPS. I then share this links with my learners. |
| 11 | What is the impact of connectivism and ICT support strategies on progressed learners' performance in Maths? | The ability to digitally take notes and share it with other learners has made teaching and learning more effective especially for progressed learners. Technology is mostly exciting tool to use not just for learners but also for us as teachers. It makes teaching easy and more learner centred. Our learners are eager though not all of them. Knowledge flows easily and quickly and learners are exposed to new and relevant information at all times. It also helps in that learners can find a number of methods to come to one single solution, so I encourage them to find ways different from what we used in class. Websites are rich with information which can benefit progressed learners and a learner just needs to click a button to learn. Our smart boards are also linked with our learners' tablets. So our learners have the ability to digitally take notes share it with other learners and this has made teaching and learning more effective especially for progressed learners. Another important factor I noticed is that this encourages peer learning. Learners can share information, revise, cross-reference with a number of sources and themselves and they engage me if they find contractionary information. In this process, learners develop research skills, and this is a vital learning skill which learners could further apply in their process of learning. There is a significant interest and improvement in performance as I have shown in my tracking mark schedules. A learners' autonomy is encouraged. Learners can learn even when they are home. My learners are able to find knowledge on their own and share with each other in the group. The role of a learner is thus progressively changing from them being passive containers, which must be filled with knowledge to being an active participant of the educational process who creates their own knowledge and surrounding reality. Learning is limitless and knowledge comes from anywhere, it goes beyond the normal classroom. |
| 12 | What are some of the perceived benefits of using connectivism and ICT in your pedagogy in | In this process learners develop research skills, and this is a vital learning skill which learners could further apply in their process of learning. Simultaneously finding the best methods of gaining from various sources with learners makes teachers co-learners as opposed to the sole wellspring. Certain learners take the leadership to maintain these links and ensure that the flow of information is properly managed, there is also improved learner attendance due to the introduction of ICT. Progressed learners do not naturally participate in a traditional learning set-up for various reasons, but these platforms have offered |

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| | teaching Mathematics for progressed learners? | some form of a safe space to engage at times privately with me. Concept to research to probe prior knowledge, they come up with brilliant inventions from the internet. ICT supported lessons are simple because they bring in a number of methods. Learners can re-wind or pause for emphasis and continuous practice. They also work together and share information, This encourages peer learning. Technology allows for revision and cross reference. They learn how to look for information.<br><br>Learning in their home comfort also improves participation. Learning is now learner focused and centred. Learning has become continuous beyond the classroom and limitless. There is evidence in terms of participation and performance. |
| 13 | How do the progressed learners react towards learning using connectivism and ICT? | As I have already stated, learner autonomy is encouraged and progressed learners do not naturally participate in a traditional learning set-up some are shy and some are so self-conscious, but these platforms have offered some safe space to engage at times privately with me. Time frames for learning offer flexibility and some form of comfort. Some have even taken a leadership role as they are admins to these groups. Sometimes these apps offer complicated information for my learners, but I always tell them am available for clarity. |
| 14 | In your opinion, can you say ICT has assisted you to support progressed learners? How? | ICT accommodates all learner ability. Yes.<br><br>As already indicated and demonstrated, I use videos to demonstrate, to drilling certain concepts, it does complement to the way we do in class, above everything their marks are improving. |
| 15 | Has the introduction of connectivism in ICT made support for progressed learners easy? How? | It indeed has, I am able to reach them even afterschool. I am able to sent them a lot of exemplars and links which are helpful. They too are very involved, the role of a pupil is thus progressively changing – from them being passive containers, which must be filled with knowledge, to an active participant of the educational process, who creates their own knowledge and surrounding reality. Nut I can also say No, the content has not changed at all, but multiple solutions assist which are offered by video tutorials. Availability of help from these groups is also helpful. My easy to reach and their willingness to engage in these WhatsApp groups also assists. |
| 16 | How does ICT and connectivism affect the classroom atmosphere and learner discipline? | Certain learners take the learnership roles to maintain these links and ensure that the flow of information is properly managed. Our class WhatsApp groups has rules and guidelines for usage. These assist with issues around learner conduct in general. In the beginning it was hard because these learners were not taking these groups seriously. I first set boundaries through classroom on these platforms. Classroom with mixed bright learners is quiet intimidating for these learners. When you give learners a concept to research to probe prior knowledge they come up with brilliant inventions from the internet. The small support groups are very easy to manage and easy to follow interactions. |
| 17 | What challenges are you facing in integrating connectivism and ICT into teaching Mathematics for progressed learners? | One issue I have realised is lack of interest and at times poor participation. Secondly the fact that I post materials online some learners miss face to face lessons with a hope to catch up from these platform's. I asked three learners who were not a part of any study group why they chose not to be, and they all indicated that they do not have any interest in this. The absence of learners from these groups or class places them at a disadvantage because certain discussions are still being carried on at school and teachers still like to continue with face-to-face teaching to correct some of the misconception |

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| | | learners may come across from digital platforms. Another problem, our schools have been targeted by criminals and all our laptops were stolen. One of our biggest rules with my learners is compassion in these groups which to some extent manages bullying. Not interested in being in WhatsApp groups or not liking Facebook app. |
| 18 | How has using connectivism and ICT to deliver content knowledge affected midterm pass rates for progressed learners? | Looking at prelims which were part of term 3 due to Covid, we only did school based tests but I can share with you my mark schedules where I track my learners performance. The performance gradually improving. We depended solely on these platforms now to teach with what is currently happening. Simultaneously, finding the best methods of gaining from various sources along with learners makes teachers co-learners as opposed to the sole wellspring of information.. |
| 19 | What is the impact of using connectivism with ICT on progressed learners' achievement? | When you give learners a concept to research to probe prior knowledge, they come up with brilliant inventions from the internet. Progressed learners do not naturally participate in a traditional learning set-up for various reasons, but these platforms have offered some a safe space to engage at times privately with me. Results have improved if you compare with their grade 11 results and now I have level 5 and 6 pass. |
| 20 | How do the networks enhance by ICT support learners with homework? | As already said earlier homework is now a part of continuous learning. There is always work sent through a link at home but my learners also prefer to stay late to maximize our wi-fi in order to link up with their groups (connections as you call them). Utilization of ICTs in instructing makes learning more creative, intriguing, intuitive, simple and successful. |
| 21 | What is the link between the current curriculum and the available connectivism and ICT strategies at your school? | Utilization of ICTs in instructing makes learning more creative, intriguing, intuitive, simple and successful, the department has loaded our smartboard with E- content, there is Thutong portal but our lesson plans are not created to accommodate ICT type of learning. It is up to me to research and advice my learners as where to look for resources. |

| NAME | AGE | GENDER | POSITION | SERVICE | QUALIFICATIONS | SUBJECTS | NATURE OF APPOINTMENT |
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| PARTICIPANT F | 57 | MALE | DEPUTY | 22 | ACE | MATHEMATICS | PERMANENT |

| No. | Questions | Candidate F |
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| 1 | How do you go about using connectivism in integrating ICT in your lessons to support progressed learners in Mathematics? | We have laptops in classes and each learner has a tablet which has content and they may use it anywhere. All our classes are installed with Interactive White Boards. There is no need for learners to take notes, these interactive white boards are linked to learners' tablets or cell phones through Bluetooth or Share it, to link the devices to take notes.<br>We have created WhatsApp groups; we use Facebook and Telegram applications to enhance our classroom discussions. We have even gone as far as using Microsoft Teams but these only happen while learners are at school using smartboards. Our school is an ICT pilot school so we have introduced the use of small teams afternoon lectures and discussion groups where learners sit in for extra hour of discussions and support classes but we do not do it quite often only where there is a concept, I need to further explain and it is only for my progressed learners because it is quite expensive.<br>We download a number of online resources which we use to teach.<br>We have selected groups using our tablets where we further discuss school work.<br>We use every resource available to facilitate and support our Grade 12 learners who are really struggling. |
| 2 | When did you start teaching progressed learners using the connectivism model in ICT? | We used technology at a high level since 2018 when the MEC changed our school into an ICT school as a pilot township program, we are now a paperless school. |
| 3 | How do you feel about teaching progressed learners with ICT using the connectivism theory? | I was not confident at the beginning but we had every necessary IT support and training from the department to allow for a smooth transition. I can confidently say teaching with all these devices has made learning exciting and less paper work. My learners are always in touch and teaching and learning has extended beyond the classroom. |
| 4 | What type of ICT tools do you prefer in supporting progressed learners in Mathematics and why? | Like I have already indicated, we use 1.whiteboards, which uses magic pens to write, highlight and download resources.<br>2. We use Share it although they only use when they are in their class support sessions. The shared information can be used at a later stage. One of the techniques I use to give learners extra work is that I send them a link with work that needs to be done at home, they are free to discuss it in the groups for guidance or explanation.<br><br>I also have WhatsApp and Facebook groups which are used to learn. Both WhatsApp and Facebook applications were created by me and I encouraged all my learners to join these groups and my learners are very active in seeking and sharing knowledge for clarity and even showcase their findings within stated timeframes. Due to the availability of school Wi-fi, even when I am absent, I use the virtual classroom to connect with my learners through Microsoft Teams or Zoom and our daily communications is WhatsApp. |
| 5 | How effective are the networks formed by progressed learners through learning with ICT? | About 95% of our learners participate in these way of learning. We have a number of ICT tools and unlimited Wi-fi so it is very effective. Because we also loan them tablets to take home with, our learners engage me even after normal contact time. They have a number of study groups and sometimes these groups were personally initiated by learners without an educators involvement. |

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| 6 | In which part of the lessons or content do you think it is appropriate to use ICT to support progressed learners and why? | I teach with technology all the time because we are a paperless school. What is critical I think is how do I teach with technology. I use the magic pen on our digital boards for emphasis, reinforcement and to highlight important concepts. I download videos and they offer tutorials, we pause, we repeat concepts as we teach.<br><br>We use applications as also demonstrated such as Geogebra and Desmos as manipulatives and to try to make these concepts a bit concrete. (Demo on Desmos using google classroom was done). There is an app called Desmos which is a good teaching and digital worksheet which assist in teaching and reinforcement for further understanding.<br><br>We use digital worksheets, Thutong portal resources and other online materials learners can find in order to help them study. We really do not specify which part of lesson, at times I introduce my lesson with a video tutorial, at times I send a link to my learners for pre-preparation, at times I give short class activities for reinforcement. We have however not as yet used these portals for formal assessment. We also give informal activities for support and home activities. |
| 7 | Does the connectivism networks extend beyond the classroom and what are the ICT resources progressed learners use beyond the classroom? | Our learners collaborate with a large group of other learners from our cluster through their WhatsApp groups and Facebook links. We also host SSIP classes at another school and our learners attend support sessions on Saturdays. We have agreed that our chat group ends at 20:30 Mondays to Thursdays and it is a very small group of learners who really need extra push. So I do make time to send voice notes, video lessons and worksheets and they can engage with me at the comfort of their homes. |
| **8** | How often do you integrate ICT in your lesson planning for progressed learners and why do you choose to do so? | Always we are an ICT school, so teaching and learning is digital. Although you can see we still use exercise books and paper for exams and formal work. |
| 9 | How do you think connectivism used within ICT contributes towards content delivery in teaching progressed learners? | Teaching with technology help these learners to have access to multiple sources of information. They do depend on me but they also are able to download their own materials. They easily share information among themselves. We get multiple solutions and others are quite simplified and my learners can choose which is the most easier method.The learners participation is high because these learners love technology, they engage among themselves and some of these study groups are not just our learners only but from other schools. There is a high level of co-operative learning and sharing of ideas and my learner kind of choose how to learn and I must say this type of learning is more learner focused.<br><br>We teach through technology always, for instance the Geogebra app is a practical way of bringing abstract Mathematics concepts to the learners for their easy comprehension especially progressed learners. You-tube videos offer demos of a number of concepts, we share new knowledge amongst us as Mathematics teachers through our PLCs and we are connected via WhatsApp or our monthly Microsoft teams meetings. The same applies to our learners, they |

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| | | share video tutorials, voice notes and other sources they obtain either online or from class. With the wide range of teaching and learning material available I select those that suit the students' needs according to their level and ability. Apps such as Desmos as well offer beautiful digital worksheets which offer reinforcement, continuous practice and they are easy to embed notes and explanations. |
| 10 | How are you creating content in Maths suitable for progressed learners using ICT network tools? | Its already explained I used apps such as Geogebra. The Geogebra app is a practical way of bringing abstract Mathematical concepts to the learners for their easy comprehension especially progressed learners. Remember I have already demonstrated how magic pen and Desmos concepts work. I obtain concepts from my ATP and link to this Apps and it works easily.<br><br>There is no specific way prescribed by the department on how we should teach we use E-text books on the Whiteboards and learners laptops for resources. Learners are able to find new knowledge and solutions from these portals and other approved websites. |
| 11 | What is the impact of connectivism and ICT support strategies on progressed learners' performance in Maths? | My learners really participate, they work together, they assist each other even when they are not at school, learning takes place even when they are at home , so with Maths constant practice is recommended, one thing that I have come to really appreciate since we started going paperless, our learners they are not passively discussing, rather they engage in building models and participation in virtual world's as they construct knowledge.<br><br>It is amazing to see the level of support we obtain from department and other stake holders to ensure that teaching with technology becomes meaningful. Since 2018, our matric results have improved for mathematics and science. The pressure is on as a pilot school to ensure that the way of learning is actually effective. Our communication has improved, we share ideas and solutions.<br><br>Our classes are always full because these learners enjoy exploring concepts using ICT's. I track those who are quite in these networks and I message them privately at times, you find that a learner is struggling and this private engagement helps him to explain what the challenges may be.<br><br>ICT encourages innovation and creativity not just in Mathematics but in other subjects and the learners role has increased. |
| 12 | What are some of the perceived benefits of using connectivism and ICT in your pedagogy in teaching Mathematics for progressed learners? | I have said a lot already about the benefit or impact. The first thing is our performance has improved, not just Mathematics but our NCS pass percentage. Another indicator is improved attendance and participation. Our classes are always full because these learners enjoy exploring concepts using ICT's.<br><br>A number of solutions are shared among learners and learning is continuous and there is a high level of student engagement and other information is obtained from Thutong's portal. Leaners do not only depend on each other as information sources on the internet and this opens up a bigger learning platform.<br><br>One thing that I have come to discover is Information does not only reside with humans but can also be obtained from websites. I still |

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| | | encourage them to also use other sources such as Thutong portal. There are also a huge library locally which contains a lot of resources. Complicated concepts are brought to live through the use of video or game-like applications to make these learners really understand these concepts to the learners for their easy comprehension especially progressed learners. Learners also can learn even after school at home and are open to engage other learners. teaching with ICT is very flexible and exciting I must admit. |
| 13 | How do the progressed learners react towards learning using connectivism and ICT? | Some are still struggling but with continuous practice and exposure to the number of exam papers we download, there is a positive outcome. I encourage them to freely participate as the groups are quite small. As I have already indicated, I track those who are quite in these networks and I direct message them to find out the reasons for their participation. |
| 14 | In your opinion, can you say ICT has assisted you to support progressed learners? How? | Yes very much, I must admit as an older teacher in the beginning it was very difficult but we were supported by external service providers and the transition occurred ultimately. |
| 15 | Has the introduction of connectivism in ICT made support for progressed learners easy? How? | Not easy I must say because some of these learners really lack foundation, some are de-motivated and have given up. What technology has done is not fix all but has offered ways to make Mathematics be learnt in a concrete way, it has brought to the learners accessibility of multiple resources and enhances drill and practice. Willing learners are able to support and help each other. They are very active and talk to me even early evenings. |
| 16 | How does ICT and connectivism affect the classroom atmosphere and learner discipline? | We have a policy which guides the times, language and participation procedures in these platforms with my learners. It is a very informal for controlled spaces. The uniformity of this networks make it a relaxed environment which allows learners to participate. There are however incidents to misuse as you know learners will always find their way if not continuously monitored. Also I monitor participation and try to encourage the quite once to participate. |
| 17 | What challenges are you facing in integrating connectivism and ICT into teaching Mathematics for progressed learners? | Load shedding is our worst challenge. We do not have a back up generator and our classes are paperless, you can imagine what happens when the power goes. Another interesting fact our ATP are loaded with a content which needs to be completed in about 8 months because of the workload is heavy for these learners, content is not fully explored due to time constraints. Some learners just lack interest in participating.<br>Our school also became a target for burglaries as was known that the school and learners have these ICT tools. My observation is it encourages educator absenteeism as they know they will be able to connect with their learners wherever they are. |
| 18 | How has using connectivism and ICT to deliver content knowledge affected midterm pass rates for progressed learners? | Looking at my tracking tool, I can really confirm that our results have improved and our prelims will give us a clearer picture of what to expect in the final exams. Due to Covid, our mid term was only SBA meaning it was not a full exam. |

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| 19 | What is the impact of using connectivism with ICT on progressed learners' achievement? | Positive impact. Class attendance has improved, learner participation is also quite good. They are quite used to exam questions due to continuous practice. Our results have improved since 2016. |
| 20 | How do the networks enhance by ICT support learners with homework? | Learning happens until 8pm at home. Some of these learners use these platforms to seek clarity from their peers, an opportunity a classroom does not offer. |
| 21 | What is the link between the current curriculum and the available connectivism and ICT strategies at your school? | We have Thutong portal and we also have Siyavula website which offer tutorials and expanded resources. The rest is up to us to link all the resources to the days' lesson. There is no prescribed way on how to either support progressed learners or integrate ICT to a lesson. |

**BIOGRAPHICAL INFORMATION**

| NAME | AGE | GENDER | POSITION | NO OF YEARS IN SERVICE | QUALIFICATION | SUBJECTS | NATURE OF APPOINTMENT |
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| PARTICIPANT J | 47 | Male | PL 1 TEACHERS | 11 | BED | MATHEMATICS & MATHS LITERACY | PERMANANET |

| No. | Questions | Candidate J |
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| 1 | How do you go about using connectivism in integrating ICT in your lessons to support progressed learners in Mathematics? | The use of smartboard plays a pivotal role in the dissemination and sharing of information to learners during the teaching and learning process. Certain concepts that are challenging can be videoed and uploaded on the board for the repetitive purpose.<br><br>We also use lap tops, each learner has a working space and our laptops and tablets have Thutong portal which has curriculum materials for all the subjects.<br><br>We also use tablets for only grade 12 learners. These gadgets have online materials which learners use both at school and at home to learn. I sent work via various links which assist in facilitating teaching. Due to recent covid issues I depend more on these connections as |

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| | | discussion groups and virtual classes to teach and learn. |
| 2 | When did you start teaching progressed learners using the connectivism model in ICT? | Since the advent of Technologies at schools and since the inception of smartboards at school level. |
| 3 | How do you feel about teaching progressed learners with ICT using the connectivism theory? | There are about 60% of learners if I have to roughly estimate of learners who participate in this groups and are actually active. With the data costs, I think this will improve with policy changes we are adopting for our school. I feel like since I used more of this gadgets, teaching is simplified as it enables the teacher to prepare each visual aids and this can hold the attention of learners. I have taught Mathematics for 11 years and the recent 5 years has changed to using the assistance of computers at our school. I must indicate that I was not totally responsible for all the networks and their administration, one member of the group become an administrator responsible for adding members' information. Some of this links occur between our learners and other schools and may have been formulated at their support classes or SSIP classes. |
| 4 | What type of ICT tools do you prefer in supporting progressed learners in Mathematics and why? | Our learners have created study networks, I am part of some not all this networks especially for Mathematics. I was not totally responsible for all the networks and their administration Although I did not create this groups, my class has a Wats app group which I joined and I use it to facilitate their discussions. I prefer using Facebook, Telegram, share it and WhatsApp platforms since learners like using them to chat. I can prepare a threaded conversation and upload videos to enhance the lesson. With data prices, WhatsApp, Telegram and share it are most used by our learners while Zoom and Microsoft Teams are basically used at school to connect |

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| | | with learners who may be absent with technology, no learner should be left behind,<br><br>Telegrams work best for us and what's app as instant messenger, I sent hyperlinks of their e-books and notes to explain and these works easily as learners download the content and notes and work. |
| 5 | How effective are the networks formed by progressed learners through learning with ICT? | Learners can easily share information and help each other on arousing problems pertaining to the subject. It works as a good discussion platform where ideas are exchanged. This is done to the usage of WhatsApp and Facebook platforms. "one of the techniques I use to give learners extra work is that I sent them Wats app link with work that needs to be done at home, they are free to discuss it in the group what's app for guidance or explanations". I further sent voice notes explaining my methods or a link to a YouTube video with demonstrations |
| 6 | In which part of the lessons or content do you think it is appropriate to use ICT to support progressed learners and why? | Data handling and geometry where figures and diagrams can be shared and interpreted with ease.<br><br>I use videos for support strategies and I use these mostly for formative assessment. I also use nice video demonstrations for reinforcement as learners sometimes requires multiple explanation platforms.<br><br>At times I choose to introduce my lesson using a YouTube video. |
| 7 | Does the connectivism networks extend beyond the classroom and what are the ICT resources progressed learners use beyond the classroom? | Yes, learners can utilise their phones or tablets if available to access lessons and information posted either on google drive or on WhatsApp.<br>Some of our study groups occurs after ours but at school. Grade 12 learners do not leave school at the normal time, they stay behind for revision, I use a smart board if I am not at school and facilitate a Teams discussion or upload a video of my session and these learners are able to watch in smaller afternoon groups. I must indicate that not all learners |

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| | | are fully in participation for this extra session after hours for a number of reasons.<br>Most of this groups occur after contact time, learners use their cell phones and tablets to download videos, to chat and to discuss schoolwork given. There is Thutong portal which has past question papers with memos and learners download this material and share among each other as revision. At times when a learner is absent, other learners sent work via various links home to assist such a learner. This became very effective during the covid time, learning happened while a learner was in isolation or absent for other valid reasons. |
| **8** | How often do you integrate ICT in your lesson planning for progressed learners and why do you choose to do so? | Almost every time since it makes planning and presentation of lesson very user friendly, just a touch of a button. |
| 9 | How do you think connectivism used within ICT contributes towards content delivery in teaching progressed learners? | More activities relating to the subject content can be shared and the objectives of the lessons can be easily attained<br><br>Various learning strategies which are goal orientated are shared which are much simplifies.<br><br>The repeat button manages speed, enhances reinforcement and repetitiveness, this helps in content deliver as a strategy on its own.<br><br>The use of multiple data sources also assists these learners as other illustrations from other learners or YouTube videos assist in relaying the content message |
| 10 | How are you creating content in Maths suitable for progressed learners using ICT network tools? | The use of graphs, mathematical diagrams and videos uploaded on smartboard can be used over and over again<br>to enhance teaching. The same information can be shared using WhatsApp platforms.<br>I further align curriculum content with easy resources I find online as exemplar questions or demonstrations. It is important to work within the set curriculum and ensure that these learners only focus on key curriculum concepts and approved methods used.<br>Geo gebra is one exiting concept you can find online; its demonstrations assist progressed learners to crasp the content easily. Learners |

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| | | basically learn through sound, colour and practical demonstrations. |
| 11 | What is the impact of connectivism and ICT support strategies on progressed learners' performance in Maths? | There's a sign of progress even though at times challenges are not met in terms of WhatsApp when learners don't have to access information. Improved performance is one of the impacts of using this teaching strategies.<br><br>Learner involvement keeps improving which is not the case in the classrooms. Learners are able to find the days work even when they are at home, so there is no loss of contact time even when a learner is absent. I believe these are visible and measurable impact I have observed with my learners. Teaching is now user friendly, trending and latest information relating to the subject content can be shared. |
| 12 | What are some of the perceived benefits of using connectivism and ICT in your pedagogy in teaching Mathematics for progressed learners? | Teaching is now user friendly, trending and latest information relating to the subject content can be shared.<br>Learners are able to assist each other in the learning process. There is a vast information development through this links and sharing. Learners learn together in a collaborative way. Learners are able to come up with many different methods towards attaining a solution. There is a visible learning flexibility for both the learner and the teacher. With the catch-up lessons, learners are free to replay the lesson at their own spare time or during afternoon support sessions. What happens in this network is learners do their own research online, share their findings and a learner can compare different findings and comprehend the best methods to apply" |
| 13 | How do the progressed learners react towards learning using connectivism and ICT? | Learners are always enthusiastic and show positive signs since they embrace ICT and Technology. Lessons are simpler to follow. these materials not only benefit low ability learners but are shared among various networks as part of their revision. There is a range of methods which learners can choose to use as per their ability. Learning has also been learner focused and it takes into consideration each individual learner needs. Learners not only learn from the educator but from each other. Their level of engagement is also improved and my role is just to guide the discussions, encourage the silent once to have a voice. We use virtual worlds to teach complex topics, when one travels into the virtual world, it becomes easier to understand a difficult concept which is simulated by such a game The interactions are very exciting, you can actually see that these learners are consulting a number of data sources. Learners are able to consult a number of data sources and refer to such in presenting their findings. One can note that in Mathematics |

| | | |
|---|---|---|
| | | information does not only reside with human but can also be obtained from digital devices. I encourage them to use the libraries, old material from past memorandums, videos as long as it will help them understand a concept and perform better. The good part about these platforms, they are not time bounds, learners can ask a number of clarity seeking questions anytime and a response shall be given either by a fellow learner or me. The tempo of the learning is basically controlled by a learner and because the number of learners who do Mathematics is very small, this platform allows me to reach all of them individually daily and this has improved their performance, this personal attention makes these learners try to participate in these discussions. |
| 14 | In your opinion, can you say ICT has assisted you to support progressed learners? How? | Yes, learners and teachers can easily access information available and exchange information discovered to the benefit of the entire class. What we do is called continuous classroom which extends to home, it is no longer the traditional homework. I identify my progressed learners' needs and guide them to the websites where they can find the correct information and encourage them to find solutions or create more knowledge and share it among themselves. Learners are free and are not scared to participate using these platforms<br>Their performance is improving each term. Theses learners are really motivated, and I believe with the effort they have given, their matric results will be good. They manage their own learning, and they are in control of how they want to learn |
| 15 | Has the introduction of connectivism in ICT made support for progressed learners easy? How? | Yes, most learners have smartphones, and their learning and teaching environment (classes) are installed with smartboards. Teachers can upload files, videos and relevant data to be used by learners at their own time. The use of these strategies has compensated the normal Saturday SSIP lessons, learners are within our reach at all times. There is also an abundance of resources, cites to look into for better explanations and videos to teach with. |
| 16 | How does ICT and connectivism affect the classroom atmosphere and learner discipline? | Discipline is highly monitored and since there is smartboard, teachers can easily control learner's behaviour and ascertain challenges easily. There are rules we have also put into place to manage the general learner conduct. I have also made the parents aware these platforms act as virtual classroom and classroom apply wherever they are in |

| | | |
|---|---|---|
| | | use. The group administrators are learners, and they automatically take up a leadership and responsibility role to ensure the functionality of these networks and ill-discipline members are always made aware of the school rules and code of conduct for learners |
| 17 | What challenges are you facing in integrating connectivism and ICT into teaching Mathematics for progressed learners? | Vandalism of smartboards, lack of internet. Connectivity and challenges of load-shedding. |
| 18 | How has using connectivism and ICT to deliver content knowledge affected midterm pass rates for progressed learners? | Unfortunately, due to lockdown and the Covid epidemic it was impossible to assess the learners for midterm assessment. |
| 19 | What is the impact of using connectivism with ICT on progressed learners' achievement? | There are signs of improvements and moderate level of achievement since learners can comprehend the subject content with ease. |
| 20 | How do the networks enhance by ICT support learners with homework? | Home works can be uploaded on their gadget and different platforms they use on daily basis like WhatsApp and Facebook pages. What we do is called continuous classroom which extends to home, it is no longer the traditional homework. This encourages learners to participate unlike the traditional time homework whereby learners would choose even not to do it. |
| 21 | What is the link between the current curriculum and the available connectivism and ICT strategies at your school? | Most of the related subject content and curriculum issues can be easily found since one can assess the websites relevant for curriculum development like Thutong and GDE websites. |

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YUNIBESITHI YA PRETORIA

**APPENDIX F: SHEDULE FOR QUESTIONNAIRE**

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Education

# QUESTSTIONAIRE ON STRATEGIES TO PROGRESSED LEARNERS

Write the responses into the provided spaces of each question________________

**Required*

1. SECTION A: DEMOGRAPHIC INFORMATION*

   tick all that apply.

| Below 35 | Below 45 | Below 55 | Below 65 |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

2. Gender

   *Mark only one oval*

◯ Male
◯ Female
◯ Prefer not to say
◯ Other______________________________

3. Number of years in service*
   *Mark only oval.*

◯ 1-5
◯ 6-10
◯ 11-15
◯ Over 16

4. Number of years teaching Mathematics Grade 12*
   *Mark only one oval.*

- ⬭ 1-5 Years
- ⬭ 6-10 Years
- ⬭ Over 11 Years

5. Educational level*

*Mark only one oval*

- ⬭ Diploma
- ⬭ Degree/Post Grad Diploma
- ⬭ Honors Degree
- ⬭ Master's Degree and above

Other: ________________________________

Conceptual Knowledge

6. What support strategies do you employ to support progressed learners?

______________________________________________________________________

______________________________________________________________________

7. How do you use strategies?

______________________________________________________________________

______________________________________________________________________

8. Why do you use the above strategies?

______________________________________________________________________

______________________________________________________________________

9. What are the benefits of your support strategies on progressed learners?

______________________________________________________________________

______________________________________________________________________

10. What are the challenges you experience in supporting progressed?

______________________________________________________________________

______________________________________________________________________

______________________________________________________________________

11. What support does the school management offer in supporting your strategies?

____________________________________________________________________

____________________________________________________________________

12. What support does the Department of Education offer you on supporting progressed learners?

____________________________________________________________________

____________________________________________________________________

13. What is your view on progression policy in general?

____________________________________________________________________

____________________________________________________________________

Progressed learners' results analysis *Fill in the pass % of progressed learners for the past three terms*

14.9 progressed learners pass % for term 1-3 (2021)

*Tick all that apply.*

| | 0-29 | 30-39 | 40-49 | 50 and above |
|---|---|---|---|---|
| Term1 | ☐ | ☐ | ☐ | ☐ |
| Term2 | ☐ | ☐ | ☐ | ☐ |
| Term3 | ☐ | ☐ | ☐ | ☐ |
| Term4 | ☐ | ☐ | ☐ | ☐ |

## APPENDIX G: CIRCULAR 22 OF 2016

**CIRCULAR E 22 OF 2016**

Private Bag X895, Pretoria, 0001, Sol Plaatje House, 222 Struben Street, Pretoria, 0002, South Africa Tel. : (012) 357 3000, Fax: (012) 323 0601 , www.education.govza

EnquiriesMs FN Modipa
Tel 012 3574101
Fax 012 328 2128
Email Modipa.f@dbe.gov.za

TO: HEADS OF PROVINCIAL EDUCATION DEPARTMENTS
HEADS OF PROVINCIAL CURRICULUM SECTIONS
HEADS OF PROVINCIAL EXAMINATION SECTIONS
UMALUSI
NATIONAL TEACHER ORGANISATIONS
DISTRICT MANAGERS
SCHOOL PRINCIPALS

CIRCULAR E22 OF 2016

CRITERIA FOR THE IMPLEMENTATION OF PROGRESSION IN GRADES 10-12

1 . In November 2015, Circular E35 of 2015 was sent to Provincial Education Departments regarding the Criteria for the Implementation of Progression in Grades 10-11.

2. The purpose of Circular E35 of 2015 was to align the regulation with the minimum requirements of the National Senior Certificate to ensure that a learner who is progressed meets the basic criteria, which will assist the learner to cope with the demands of the next grade.

3. The criteria which were included in the above Circular, are clarified below:

(a) the learner must have failed to satisfy the promotion requirements of either Grade 10 or Grade 11, and repeated either Grade 10 or Grade 11;

(b) the learner must have passed the Language of Learning and Teaching (LoLT) and any other three of the seven subjects offered (Life Orientation included). If the Home Language is the LOLT, then only for the purpose of this criteria, a 30% mark will be accepted;

(c) the learner must have attended school on a regular basis. Absenteeism in excess of 20 days, without a valid reason, will disqualify the learner from being progressed; and*

(d) the learner must have complied with the prescribed School Based Assessment (SBA) requirements for that academic year.

4. In addition, the Minister approved for progressed learners to be allowed to choose the Multiple Examination Opportunity option in the writing of the National Senior Certificate examinations. This implies that progressed learners after the preparatory examination, and based on their performance in the preparatory examination, may choose to write all six subjects or less than the six subjects' package, in the November 2016 examination. The remaining subjects will be written in the June examination in 2017.

5. Principals must ensure that the affected learners and parents are consulted on the Multiple Examination Opportunity option. It is also important to note that the Multiple Examination Opportunity option is only applicable to progresses learners.

6. Provincial Education Departments are expected to conduct a verification of learners that are progressed as well as provide the Department of Basic Education with the number of progressed learners that have opted for the Multiple Examination Opportunity.

7. The verified number of progressed learners must be provided to the DBE by 30 August 2016. The verified number of learners that have selected the Multiple Examination Opportunity must be provided to the DBE by 14 October 2016.

8. This Circular E22 of 2016 should be read in conjunction with the following policy and regulation documents:

- National Policy Pertaining to the Programme and Promotion Requirements of the National Curriculum Statement Grades R-12;
- Regulations Pettaining to the National Curriculum Statement Grades R-12; and • Circular E35 of 2015.

Attached find the document entitled "Guideline for the Implementation of Promotion and Progression Requirements for Grade 10 — 11" (2016).

The above national policy documents and regulations are available on the Department's website: www.education.gov.za under Documents Library-Policies.

Circular E35 of 2015 is attached for ease of reference. You are kindly requested to bring the contents of this Circular to the attention of all provincial and district officials, principals and teachers of both public and independent schools.

Yours sincerely
MR.MWELI

R HM MWELI
DIRECTOR-GENERAL
DATE: 6/08/2016

## APPENDIX H: CIRCULAR E35 OF 2015

CIRCULAR E35 OF 2015

Department:

Basic Education

REPUBLIC OF SOUTH AFRICA

Private Bag X895, 0001. Sot Plaatje House, No 22 Struben Street, Pretoria, 0002, South Africa Tel:(012) 357 .3CD0, Fax: (012} 323 0601 , www.education.gov.za

TO: HEADS OF DEPARTMENTS
HEADS OF PROVINCIAL EXAMINATION SECTIONS
HEADS OF PROVINCIAL CURRICULUM SECTIONS
UMALUSI
DISTRICT MANAGERS
SCHOOL PRINCIPALS

CIRCULAR E35 OF 2015

CRITERIA FOR THE IMPLEMENTATION OF PROGRESSION GRADES TO 12.

1. The Regulations Pertaining to the National Curriculum Statement Grades R-12, promulgated per Notice No, RI 114 in Regulation Gazette No. 9886 of 28 December 2072, states that a learner may be retained only once in the Further Education and Training Phase in order to prevent the learner from being retained in this phase for longer than four years.

2. This implies that a learner who has not met the promotion requirements in either Grade 10 or Grade 1 % after repeating the grade, may be progressed to the next grade.

3 The purpose of this circular is to align the regulations above with the minimum requirements of the National Senior Certificate to ensure that a learner who is progressed meets certain basic criteria, which will assist the learner to cope with the demands of the next grade.

4. This circular provides criteria to assist school principals to determine which of the leamers referred to paragraph

5. At the meeting of the Council of Education Ministers held on 14 August 2015, it was agreed that the following criteria should be used to determine learner progression to the next grade. Learners should only be progressed if they satisfy the following criteria:



a) The learner must have failed to satisfy the promotion requirements of either Grade 10 or Grade 1 1 and repeated either Grade 10 or Grade 11;

b) The learner must have passed the Language of Learning and Teaching (LOLT) end another three of the seven subjects offered;

c) The learner must have attended school on a regular basis. Absenteeism in excess of 20 days, without a valid reason, will disqualify the learner from being progressed;

d) The learner must have complied with the prescribed school-based assessment (SBA) requirements for that academic year.

6. A leamer must satisfy all the criteria above to be considered for progression to the next grade.

7. Attached find a document entitled Guideline for the Implementation of Promotion and Progression in Grades 10 - 12 (20151 which provides further elucidation on the implementation of this dispensation and a suggested procedure for the implementation of the Regulations.

8. This circular must be implemented with immediate effect in Grade 10 and Grade 1 1

,

9. For further guidance on this matter, please contact Dr RR Poliah, on email address: Poliah r@dbe.gov.za or 012 357 3900.

10. Your support with the implementation of this circular is greatly appreciated.

Pkobela

**APPENDIX I: GUIDELINE FOR THE IMPLEMENTATION OF PROMOTION AND PROGRESSION**

basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

# GUIDELINE FOR THE IMPLEMENTATION OF PROMOTION AND PROGRESSION

REQUIREMENTS FOR GRADES 10 to 11

AUGUST 2016

## 1. INTRODUCTION

The purpose of this Guideline is to ensure the consistent and uniform application by all Provincial Education Departments (PEDS) of the Regulations penaining to the National Curriculum Statement Grades R-12, promulgated as Notice No. RI 114, in Regulation Gazette No. 9886 of 28 December 2012, which states that a learner may only be retained once in the Further Education and Training Phase in order to prevent the learner from being retained in this phase for longer than four years. This Guideline is intended to support the implementation of the current policy and proposes a consultative approach that PEDS can adopt to manage the progression of Grade 10 and 1 1 learners. Uniform application by all provinces is required to prevent discrepancies in interpretation and practice.

It needs to be noted that given the promulgation of this regulation, all PEDS are obliged to inform their schools of this policy dispensation and to ensure that this policy is appropriately applied. It is therefore necessary that the contents of this Guideline is brought to the attention of all schools in the province.

This Guideline provides a clear explanation of how and when this legislation needs to be applied and also details the criteria that needs to be applied in the implementation of this policy, coupled with the suggested consultative process that may be followed, the management of any appeals that may be presented and finally how these learners should be supported when progressed to the next grade.

## 2.APPLICATION OF THE PROGRESSION LEGISLATION IN GRADES 10-11

The legislation's intent is to uphold the best interest of the learner and to minimise unnecessary school dropout in the schooling system so that every learner has the opportunity to achieve an exit qualification such as the National Senior Certificate. Learner dropout can be attributed to frustration and loss of hope by learners who have experienced chronic patterns of underperformance in the FET phase.

The basic principle relating to this policy statement is that a learner should not spend more than four years in the phase. However, at the Council of Education Ministers (CEM) meeting held on 14 August 2015, the following criteria were adopted as pre-requisites to allowing a learner to be progressed from either Grade 10 to Grade 1 1, or from Grade 1 1 to Grade 12. These criteria are as follows:
(a)the learner must have failed to satisfy the promotion requirements of either Grade 10 or Grade 11, and repeated either Grade 10 or Grade 11; (b)the learner must have passed the Language of Learning and Teaching (LOLT) and another three of the seven subjects offered; (c)the learner must have attended school on a regular basis. Absenteeism in excess of 20 days, without a valid reason, will disqualify the learner from being progressed;

(d) the learner must have complied with the prescribed School Based Assessment (SBA) requirements for that academic year.

The learner must satisfy all of the above criteria to be progressed to the next grade.

Each of the criteria listed above is elaborated in the section that follows:

(a) Criteria 1: Failed to satisfy the Promotion Requirements of either Grade 10 or Grade 11.

The following three scenarios would be relevant in this case:

Scenario 1

A learner repeats Grade 10 and does not meet the promotion requirements at the end of the second year.

Scenario .2:

A learner has met the requirements for Grade 10, but is repeating Grade 11, and, does not meet the requirements.

Scenario 3:

A learner repeats Grade 10 but does not meet the promotion requirements. She/he is progressed to Gradel 1, She/he does not meet the promotion requirements in Gradel 1 in the first year.

(b) Criteria 2: Pass four of the seven subjects offered and one of the four subjects passed must be the Language of Learning and Teaching (LOLT). The learner must pass the Language of Learning and Teaching (LOLT), which could either be English FAL or Afrikaans FAL. The rationale for the inclusion of the LOLT is based on the principle that for the learner to succeed in the next grade, he has to be competent in the LOLT, which is one of the key determinants of success from one grade to the other. If the Home Language is the LOLT of the Learner, for the purpose of progression only, the learner must obtain 30% so as to ensure equivalence with the pass requirements for the Fist Additional Languages. One of the four subjects passed by the learner could be Life Orientation. This implies that the learner could pass three other subjects and Life Orientation.

(c) Criteria 3: Regular School Attendance

Regular school attendance will ensure that the learner has had exposure to the school curriculum for the duration of the school year. If the learner has been absent for more than 20 days, without a valid reason, this constitutes irregular attendance.

(d) Criteria 4: Compliance with the School Based Assessment (SBA) Requirements

Compliance with the SBA requirements will ensure that the learner has satisfied the assessment requirements of each of the subjects, and this will confirm the learner's commitment to the subject. Despite the fact that the learner is required to pass only four of the seven subjects, he must satisfy the SBA requirements for all subjects, including the subjects he has failed.

It needs to be noted that progression in Grades 10-12 does not guarantee the final certification of a learner in Grade 12 Such a learner must comply with the certification requirements as contemplated in paragraph 37(1) (a) of the policy document, National policy pertaining to the programme and promotion requirements of the National Curriculum Statement Grades R - 12 to enable him or her to obtain a National Senior Certificate. This implies that the learner will be allowed to repeat the writing of the National Senior Certificate (NSC) examination, in order to ensure that he he/she satisfies the requirements of the NSC, which is conditional to the shelf life of the school based assessment, However, while legislation allows for progression, a parent/guardian may decide that the learner should be retained in the same grade because it is deemed in the best educational interest of that learner. This final decision by the parent/guardian must be based on substantive evidence of the learner's holistic performance at the school and through a consultative process involving the learner, the parent, the teachers involved and any other support professionals necessary.

3. MULTIPLE EXAMINATION OPPORTUNITIES

3.1 Progressed Learners will be allowed multiple examination opportunities, which implies that the learner writes a limited number of subjects in the first sitting of the examination, and will be allowed to write the remaining subjects in a subsequent examination, in order to allow them to satisfy the outstanding requirements;

3.2 The performance of progressed learners must be monitored in the Grade 12 year, and based on the performance on the Preparatory examination, the learner should be advised to:

(a) Write the examination in a limited number of subjects in the first sitting of the end-of-year examination.

(b) Write the examination in all six subjects, provided they have demonstrated acceptable achievement levels in all six subjects.

3.3 The following criteria must be used as a guideline jn determining which learners should be allowed the Multiple

Examination Opportunity:

(a) The Learner must:

(i) Be a progressed learner

( ii) Have completed his/her SBA requirement in all seven subjects

(iii) Have attended school regularly (not absent for more the 20 days without a valid reason.

(iv) Have written the preparatory examination in ali subjects

(v) Have failed a minimum of three subjects

3.4 The Learner selecting the Multiple Examination Option must write a minimum of four subjects in his first year

(including Life Orientation) and must have written all seven subjects by the second year.

3.5 The decision to opt for the Multiple Examination Option must be made in consultation with the parents.

4. A PROPOSED CONSULTATIVE APPROACH IN THE IMPLEMENTATION OF THE PROMOTION

PROGRESSION POLICY

In the case of a learner who qualifies to be progressed, the following consultative process is suggested to ensure that all persons are involved so that an informed decision is made.

4.1 AT SCHOOL LEVEL: A PROMOTION/PROGRESSION MEETING WITH STAFF

It is necessary for a school to hold a special meeting of relevant subject staff to evaluate each learner that has not met the promotion requirements more than once in grade 10 or 11 in order to decide whether the learner should be retained. Due consideration should be given to the following:

(a) Were parents/ guardians kept informed of the learner's poor performance on a regular basis despite continued underperformance by the learner?

(b) Establish whether the learner responded positively to the curriculum intervention and support strategies provided by the school, to assist low achieving learners to improve their performance.

(c) Evaluate the attendance history of the learner throughout the year to establish whether absence was with or without valid reasons

(d) Establish if the learner was absent from tests, examinations and other internal assessments, without a valid reason.

(e) Evaluate the general behaviour and attitude of the learner towards his /her schoolwork.

(f) Consider any psychosocial support needs that may have contributed to the learner's low levels of motivation and subsequent poor performance in grade 10 or grade 11.

Each learner's case must be evaluated holistically with supporting evidence collected by the subject teachers throughout the school year. This will enable the principal to advice the parent comprehensively, on the retention or progression of the learner concerned.

4.2 A CONSULTATIVE MEETING WITH THE PARENTS/GUARDIANS

If there is consensus among all subject teachers during the promotion/progression meeting that the learner should be retained in the current grade, then a meeting must be held with the parent/guardian so that the advice is carefully and clearly explained by the school and understood by the parent/guardian before the learner's school report is handed to them. This meeting should be held by the School Management Team and the meeting should include a discussion of the following:

a The conditions for retention must be presented to the parent/ guardian and the learner. Provide enough detail and explain the performance of the learner with supporting evidence.

(b) The educational advantages of retaining the learner should be clearly explained to the parent/ guardian.

(c) Present the option for the learner to change subjects. The implications of the subject changes must be clearly explained.

(d) The differentiated academic support that will be provided by the school to the learner must be explained to the parent/ guardian.

(e) Discuss the alternate or specialised support that the parent may want to access and provide for the learner to supplement the academic support provided by the school.

(0 The School Management Team must also provide details of the alternate pathways that may be followed by the learner. The benefits and implications of options available must be clearly explained.

(g) The signing of the Partnership Contract which emphasises the joint responsibility for the decision that has been taken. It stipulates the collaborative support, responsibility and commitment to ensure regular school attendance, completion of School Based Assessment Tasks and setting achievable targets to track the learner's progress. It must be printed in duplicate. Both copies must be signed by the learner, parent/guardian and a representative of the school. This document is an undertaking in good faith, of the key stakeholder’s commitment to motivate the leamer to succeed in his/her renewed efforts to make the required academic progress. One copy must be kept on file at the school and the other remains with the parent/guardian. It should be used as an accountability tool to monitor progress or lapses made during the course of the year.

## 4.3 ARRIVING AT A FINAL DECISION

(a) The decision reached at this meeting must be reflected on the learners report card. If the learner is retained, this must be confirmed in writing by the parent.

(b) Should the parent not agree to the retention of the learner, the learner must be progressed to the next grade and the report card must clearly reflect that the learner has not met the promotion requirements for the current year but has been progressed to the next grade.

(c) The conditions for progressing the learner must be fully discussed and agreed upon by the school, the parents/ guardians and the learner and should include the following conditions:

- The option for the learner to change subjects and the implications of the subject changes must be clearly explained.
- The Partnership Contract which stipulates the collaborative support, responsibility and commitment of both parties must be completed and signed.
- The differentiated support that will be provided by the school to the learner must be outlined so that the parent/guardian can also consider supplementary interventions for the learner.

## APPENDIX J: APPEAL PROCESS

A parent or guardian has a right to appeal the final decision made by the school to progress or retain a child. To appeal a progression or retention decision, the parent/guardian must submit a written request, not later than three (3) days after the official opening of schools, to the school principal specifying the reasons why the progression or retention decision is being contested.

Within fourteen (14) working days of receiving a request to appeal, the Head of Department or his/her designee shall make a final determination in this regard. The onus shall be on the parent as the appealing party to show why the progression or retention decision should be overruled.

6 CURRICULUM SUPPORT FOR THE PROGRESSED LEARNER

Districts and schools must have clearly articulated intervention strategies that include an early identification of low achievers or at-risk learners so that the school, district and province can develop and implement additional learning opportunities through meaningful extended day/year-long programmes outside of regular school hours to build the selfesteem of these learners and facilitate their social adjustment, or facilitate their access to alternate career pathways that are available locally.

Curriculum support responsibilities: may be categorized as follows:

6.1 District Based Support Teams (DBST)

- Keep a register/database of progressed learners
- The data base should reflect the subjects that placed the learner at risk
- The data base should be monitored biannually (July/November) to monitor progress of the learners • Ensure that parents are informed

(biannually or quarterly) of learners performance/progress and the proposed action to improve performance

- Co-ordinate a district wide support programme to assist learners at risk
- Support schools to identify core content per subject that progressed learners should master as part of the remedial plan
- Subject Advisors to assist teachers in crafting intervention strategies and improvement plans as per subject specifics.
- Offer ongoing training to schools and teachers on teaching and learning, communication and social and behaviorai factors.

6.2 School based Support Teams (SBST)/institutional Level Support Teams ( ILST)

- Initial identification of learners at risk and compile a (quarterly/biannual) database
- Monitor and report on progress of learners at risk / progressed learners
- Develop and implement remedial programme to support under-performing learners e.g. study guides, previous question papers and memoranda, extra classes during holidays or weekends
- Identify core content per subject that progressed learners should master as part of the remedial plan • Ensure that there is regular testing and re-testing of subject content areas that challenge leamers.
- Inform parents (quarterly/biannually) of identified learners performance/progress and the proposed action to improve performance
- Offer regular meetings (quarterly/biannually) with parents to address progress and challenges

- Offer workshops for parents of identified learners to support teaching and learning.

6.3 Parents

- Regularly control and monitor learner's tasks/homework, preparation for projects and readiness for tests/examinations.
- Attend meetings as requested by School Management Teams
- Regularly visit the school to enquire about the progress of their children
- Where possible parents should arrange additional tuition in identified subjects based on the performance of the learner
- Parents must ensure that learners complete the remedial programmes successfully

7 MONITORING OF POLICY IMPLEMENTATION BY PROVINCIAL EDUCATION DEPARTMENT

The Provincial Education Depanment must monitor the implementation of this guideline and more specifically PEDS must ensure compliance to the Progression Policy across all schools. To ensure compliance the PED must undertake the following:

(a) The PED, through the district ofice must conduct regular inspections/spot checks of the Learner Schedules and Learner Report Cards to ensure that progressions are carried out as per policy.

(b) A checklist could be developed by the province, for use during the conduct of the spot checks, which must be completed by the official conducting the spot check and signed by the principal. This will serve to confirm that the school has adhered to the stipulations of the promotion and progression requirements.

(c) The PED must track the performance of the learners across the different grades to verify that the learner has failed a grade within the phase, and satisfied the other criteria listed, before the learner can be progressed. This will also assist in the case where learners are transferred to another school.

## 8 CONCLUSION

The application of the policy on promotion• and progression needs to be managed with discretion taking into consideration, the best interest of the learner and ensuring that the parent or guardian, is included in the decision making process. Most importantly, districts and schools must have clearly enunciated intervention strategies that include an early identification of low achievers or learners at-risk so that the school, district and province can develop and implement additional learning opportunities through meaningful extended day/year-long programmes to address the learning deficits of its learners.

## APPENDIX K: LEARNER SCRIPTS

Good!

$\frac{41}{50}$

S. MATHONSI

[redacted]

05/11/2019

QUESTION 1

1.1

1.1.1 $x; 1; -6; y; -14$

$1-x \quad -7 \quad y+6 \quad -14-y$

$-7-(1-x); \ y+6-(-7); \ -14-y-(y+6)$

$-8+x; \ y+13; \ -2y-20$

$-8+x = y+13$

$x = y+13+8$

$x = y+21 \ldots ①$

$y+13 = -2y-20 \ldots ②$ (5)

$y+2y = -20-13$

$\frac{3y}{3} = \frac{-33}{3}$

$y = -11$

$x = -11+21$

$x = 10$

$10; 1; -6; -11; -14$

$-9 \quad -7 \quad -5 \quad -3$

1.1.2 $T_1 = (1)^2 + (-12)(1) + 21$

$T_1 = 10$ ✓ (2)

1.2

1.2.1 $T_1$ $T_2$ $T_3$ $T_4$ $T_5$ $T_6$ $T_7$

$-1 ; 0 ; 3 ; 8 ; 15 ; 24 ; 35$

$1 \quad 3 \quad 5 \quad 7 \quad 9 \quad 11$

$2 \quad 2 \quad 2 \quad 2 \quad 2$ ✗

1.2.2 $\frac{2a}{2} = \frac{2}{2}$

$a = 1$ ✓

$3a + b = 1$

$3(1) + b = 1$

$b = 1 - 3$

$b = -2$ ✓

$a + b + c = -1$

$1 - 2 + c = -1$

$c = -1 + 2 - 1$

$c = 0$ ✓

$T_n = n^2 - 2n$ ✓ (3)

QUESTION 2

2.1

2.1.1 $T_4 = 11$ ✓

$T_5 = 14$ (1)

2.1.2 $2 ; 5 ; 8 ; 11 ; 14$

$3 \quad 3 \quad 3 \quad 3$

$T_n = 2 + (n-1)(3)$

$T_n = 2 + 3n - 3$ ✓

$T_n = 3n - 1$ ✓ (2)

2.3.2 $S_n = \frac{a(r^n - 1)}{r - 1}$

$S_8 = \left(\frac{32((\frac{3}{4})^8 - 1)}{\frac{3}{4} - 1}\right)$

(4)

$S_8 = 115,19$

2.3.3 $T_n = 32(\frac{3}{4})^{11-1}$

$= 1,8\ kg$

∴ the eleventh pass is uneconomical because is less than 2,4kg

(3)

QUESTION 3

3.1 $A = P(1+i)^n$

$\frac{2x}{x} = \frac{x(1 + \frac{0,1264}{2})^{2n}}{x}$

$2 = (\frac{1329}{1250})^{2n}$

$\frac{\log(2)}{\log(\frac{1329}{1250})} = \frac{\log(\frac{1329}{1250})^{2n}}{\log(\frac{1329}{1250})}$

(4)

$\frac{11,31}{2} = \frac{2n}{2}$

$n = 5,66$ years

3.2

3.2.1 R700 000 − R50 000

= R650 000

(1)

3.2.2 $P = \left( \frac{x[1-(1+i)^{-n}]}{i} \right)$

$$650\,000 = \left( \frac{x\left(1-(1+\frac{0,18}{12})^{-180}\right)}{\frac{0,18}{2}} \right)$$

$$\frac{650\,000 \times \frac{0,18}{2}}{(1-(1+\frac{0,18}{12})^{-180}} = \frac{x(1-(1+\frac{0,18}{12})^{-180})}{(1-(1+\frac{0,18}{12})^{-180}}$$

$$x = R10\,467,74$$

4

3.2.3

$$O.B = 10\,467,74\left(\frac{1-(1+\frac{0,18}{12})^{-180-50}}{\frac{0,18}{12}}\right)$$

$$= R597\,115,31$$

2

# INVESTIGATION

MATHEMATICS GRADE 12
SEQUENCES AND SERIES

TERM 1

MARKS:50 TIME:I HOUR

| | Mark | Learner Mark |
|---|---|---|
| Question 1 | 16 | 12 |
| Question 2 | 6 | 5 |
| Question 3 | 4 | 4 |
| Question 4 | 10 | 6 |
| Question 5 | 6 | 0 |
| Question 6 | 8 | 0 |
| TOTAL | 50 | 27 |

03/02/2020

INSTRUCTIONS

1. The question paper consists of 6 questions.
2. Answer ALL the questions on the spaces provided on the question paper.
3. Clearly show ALL calculations.
4. Write neatly and legibly.

OUESTIN 1 (16MARKS) .

50

Consider the arithmetic series 3 + 7 + 11 + 15 + 19 + 23 + 27 + ...and answer the questions ich follow. which follow.

$T_1$= ....3.... $S_1$= ....3.... (2)

(ii)(2) Express $T_1$ in terms of $S_1$

....$S_1 = T_1 = 3$....

$T_2$ =....7.... $S_2$ = ....10.... (2)

(ii)(2) Express $T_2$ in terms of $S_2$ and $S_1$.

....$T_2 = S_1 + S_2 = 13$....

$T_3$ = ....11.... ; $S_3$ = ....21.... (2)

(ii)(2) Express $T_3$ in terms of $S_3$ and $S_2$.

....$T_3 = 21 - 10 = 11$....

$T_4$= ....15.... ; $S_4$ = ....36.... (2)

(ii)(2) Express $T_4$ in terms of $S_4$ and $S_3$.

....$T_4 = S_4 - S_3 = 36 - 21 = 15$....

OUESTION 2 (6MARKS). a)(1)

From your answers in question 1 above did you observe any pattern?

b)(2) ....$T_n = 4n$....

Use this pattern you observed to express $T_{100}$ in terms of $S_{100}$ and $S_{99}$.

....$T_{100} = S_{100} - S_{99} = 34950 - 34254 = 696$....

c)

Identify a relationship among $T_n$, $S_n$ and $S_{n-1}$ where n>1 and n

....$T_n = S_n - (S_{n-1})$.... n e N, (3)

OUESTION 3 "MARKS) .

Use your formula in 2 c above to determine the value of: 51

a) $T_5$ = $S_5 - S_4 = 55 - 36 = 19$ (2) (2)

$T_6$ = $S_6 - S_5 = 78 - 55 = 23$ (2) (2)

OUESTION4 (10 MARKS).

In an arithmetic sequence $S_n = n^2 - 2n$ .

Use your formula in 2c to detennine the values of:

$T_7$ = $S_7 = 35 - S_6 = 24$
$35 - 24$ (3)
$T_7 = 11$

(3)

$T_{50}$= $S_{50} = 2400 - S_{49} = 2303$
$2400 - 2303$ (3)
$T_{50} = 97$

(3)

$T_n$ = $2n - 3$ (3)
$a = -1$
$d = 2$
$T_n = a + (n-1)d$
$T_n = -1 + (n-1)2$

(4)

OUESTION 5 (0M..\RKS)

a) Do you think o r formula in 2c above will hold for a geometric series as well? (2)

b) Motivate your response in 5a above using the following geometric series:

3 •1- 6 -1• 12+ 24 + ·



QUESTION 6( 8 MARS).

44/60

37/60 Well done!!

14/05/2020

QUESTION 1

1.1 $F'(x) = 9 - x^2$

$F'(x) = \lim_{h\to 0} \frac{F(x+h) - F(x)}{h}$

$f(x+h) = 9 - (x+h)^2$

$= 9 - (x^2 + 2xh + h^2)$

$F'(x) = \lim_{h\to 0} \frac{9 - (x^2 + 2xh + h^2) - (9 - x^2)}{h}$

$F'(x) = \lim_{h\to 0} \frac{-2xh + h^2}{h}$

$f'(x) = \lim_{h\to 0} \frac{-h(-2x + h)}{h}$

(4)

$= \lim_{h\to 0} 2x + h$

$= 2x + (0)$

$= -2x$

1.2

1.2.1 $Dx[1 + 6\sqrt{x}]$

$Dx[1 + 6x^{\frac{1}{2}}]$

$Dx[0 + 3x^{-\frac{1}{2}}]$

(2)

$Dx[3x^{-\frac{1}{2}}]$

$Dx[\frac{3}{\sqrt{x}}]$

1.2.2 $\frac{dy}{dx} = \frac{8-3x^6}{8x^5}$

$\frac{dy}{dx} = \frac{1-18x^5}{40x^4}$

$\frac{dy}{dx} = \frac{-18x^5}{40x^4}$

$\frac{dy}{dx} = 1 - \frac{9}{20}x$ | $\therefore \frac{dy}{dx} = \frac{8}{20}x = \frac{2}{5}x$ (0)

1.2.3 $y = 3x^2 + 10x$

$y = 6x + 10$ (2)

1.2.4 $f(x) = (x - \frac{3}{x})^2$

$f(x) = (x - \frac{3}{x})(x - \frac{3}{x})$

$f(x) = x^2 - 3 - 3 + \frac{9}{x^2}$

$f(x) = x^2 - 6 + 9x^{-2}$ (2)

$f(x) = 2x - 18x^{-3}$

$f(x) = 2x - \frac{18}{x^3}$

QUESTION 2

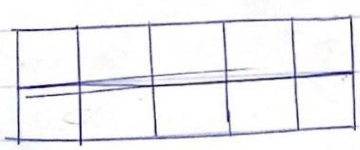
2.1 $f(x) = 3^x$

$y = 3^x$

$x = 3^y$ (1)

$f^{-1}(x) = \log_3(x)$

2.2



x-intercept, $y = 0$

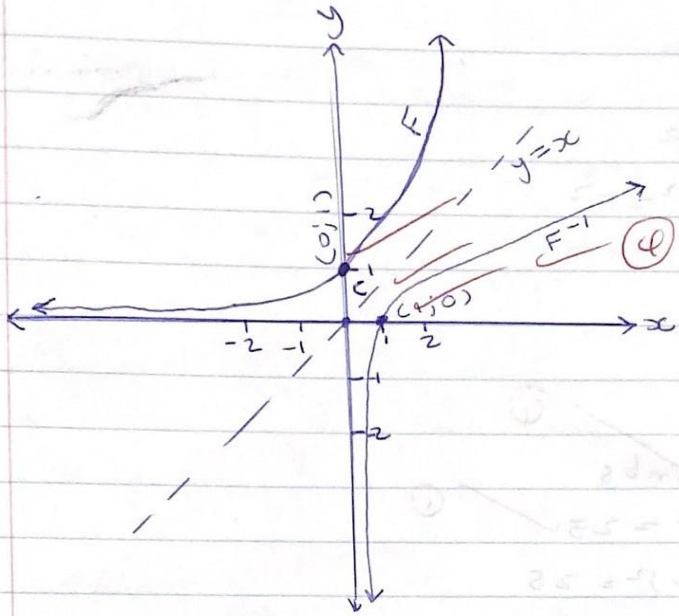
$0 = 3^x$

$x =$ undefined

y-intercept, $x = 0$

$y = 3^{(0)}$

$= 1$




2.3 $x \in R, x > 0$

2.4 $x < 0$

2.5 $y \geq -4$

2.6 $f(x) = -3^{x-2}$

$f(x) = -3^{x-2}$

QUESTION 3

3.1 C(0;5)

3.2 $y = x$

3.3

3.4 $-x^2 - 4x + 5 = -2x - 3$

$-x^2 - 4x + 2x + 5 + 3 = 0$

$-x^2 - 2x + 8 = 0$

$x^2 + 2x - 8 = 0$

$(x+4)(x-2) = 0$

$x \neq -4$ or $x = 2$

$\therefore D(2;y)$

3.5 TP(-2;-9)

GLÂES — TIAH 4

4.1 ~~$(x-a)^2+(y-b)^2=r^2$~~

$(x-a)^2+(y-b)^2=r^2$

$(0-5)^2+(4-4)^2=r^2$

$\sqrt{r^2}=\sqrt{25}$

$r^2=25$

$\sqrt{r^2}=\sqrt{25}$

$r=5$ units ④

4.2 $(x-5)^2+(y-4)^2=25$ ①

4.3 $(x-5)^2+(0-4)^2=25$

$x^2-5x-5x+25+16=25$

$x^2-10x+16=0$

$(x-8)(x-2)=0$ ②

$x\neq 8$ or $x=2$

$A(2;0)$

4.4

4.4.1 $m_{MB}=\frac{y_2-y_1}{x_2-x_1}$

$=\frac{4-0}{5-8}$ ③

$m=-\frac{4}{3}$

4.4.2 $M_{MB}\times M_{PB}=-1$

$\frac{-\frac{4}{3}\times M_{PB}}{-\frac{4}{3}}=\frac{-1}{-\frac{4}{3}}$

$M_{PB}=\frac{3}{4}$

$y-y_1=m(x-x_1)$

$y-0=\frac{3}{4}(x-8)$ ③

$y=\frac{3}{4}x-6$

4.5 $(5-5)^2+(y-4)^2=25$

$0+y^2-8y+16-25=0$

$y^2-8y-9=0$

$(y-9)(y+1)$

$y=9$ or $y\neq -1$ ∴

$y-9=0(x-5)$

$y=9$ ②

4.6 $y = \frac{3}{4}x - 6$ ②

$y = \frac{3}{4}(20) - 6$

$y = 9$

$\therefore L(20;9)$

4.7 $D_{ML} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$

$= \sqrt{(5-20)^2 + (4-9)^2}$

$= \sqrt{225 + 25}$ ②

$= \sqrt{250}$

$= 5\sqrt{10}$ units

32/50 64% good!!
10/09/2020

QUESTION 1

1.1

1.1.1 a) $P(F) = \frac{80}{150}$

$= 0,53$

b) $P(F \text{ plays tennis}) = \frac{20}{150}$ ✓ ①

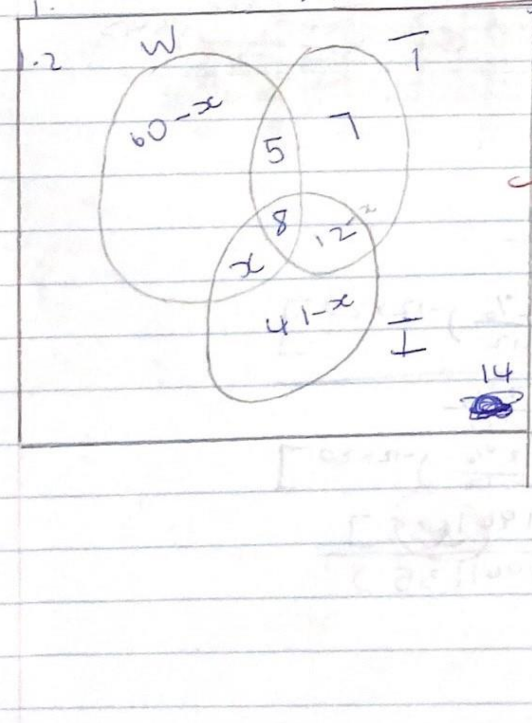
$= 0,13$

1.1.2 $P(F \text{ and } M \text{ play tennis}) = \frac{20}{150} \times \frac{50}{150}$

$P(A \text{ or } B) = \frac{20}{150} + \frac{50}{150} - 0,04 = 0,04$

$P(A \text{ or } B) = 0,43$ ∴ they are independent

1.2




✓ ②

QUESTION 2

2.1 $A = P(1-i)^n$

$\frac{11090,41}{120000} = \frac{120\,000(1-i)^{12}}{120000}$

$\sqrt[12]{0,09242008333} = \sqrt[12]{(1-i)^{12}}$

$0,82000002 - 1 = -i$

$\frac{-0,17999998 \times 100}{-1} = \frac{-i}{-1}$

$i = 18,00\%$

2.2 $1 + i_{eff} = (1 + \frac{i_m}{m})^m$

$i_{eff} = (1 + \frac{i_m}{m})^m - 1$

$= (1 + \frac{9,9\%}{12})^{12} - 1$

$= 0,1025238919 \times 100$

$= 10,25\%$

2.3 $A = 80000(1 + \frac{7,5\%}{4})^{4\times4}(1 + \frac{9,2\%}{12})^{3\times12}$

$= R107690,17$

2.4 $PV = \frac{x[1-(1+i)^{-N}]}{i}$

$500000 = \frac{x[1-(1+\frac{12\%}{12})^{-12\times20}]}{\frac{12\%}{12}}$

$5000 = x[1-(1+\frac{12\%}{12})^{-12\times20}]$

$\frac{5000}{(0,9081941635)} = \frac{x[0,9081941635]}{(0,9081941635)}$

$= R5505,43$

QUESTION 3

3.1 = ~~$\frac{52+54}{2}$~~

= ~~53~~ $Q_2 = 54$

3.2 = 90 − 34

= 56

3.2 ~~$Q_1 = \frac{43+46}{2}$~~

~~= 44,5~~

$Q_3 = 73$

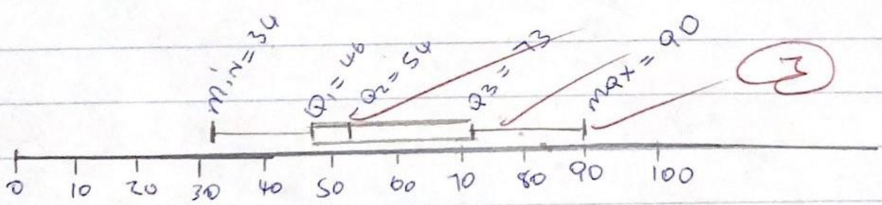
$Q_1 = 46$

$IQR = Q_3 - Q_1$

$= 73 - 46$

$= 27$

3.3




QUESTION 4

4.1

4.2 $y = a + bx$

$a = 25,23$

$b = 0,81$

$y = 25,23 + 0,81x$

4.3 $r =$ ~~0,9~~ 0,90

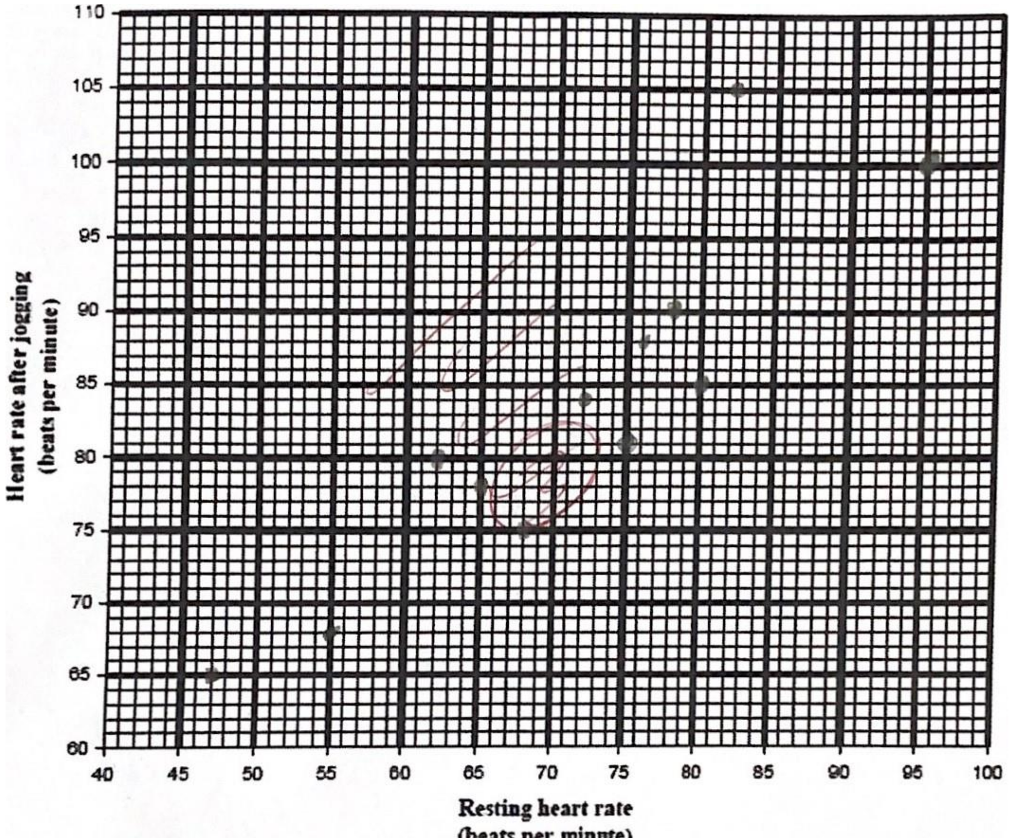
4.4 Weak data

4.5 $= 25,23 + 0,81(86)$

$y = 94,89$

# DIAGRAM SHEET 1

Scatter plot 04 g resting be ″ h ra 1 jogging




(beatsper \`

$y = -\frac{4}{3}x + \frac{82}{3}$

4.5 mtan x mrad = -1

4.6 In △ LMB

Theorem of pythegoras

$y = 5^2 - 4^2$

$y = 9$

$x^2 = 20^2 \quad \sqrt{x^2} = \sqrt{400} \quad x = 20 \quad \therefore L(20; 9)$

CA ⓘ

4.7 $D_{ML} = \sqrt{(x_a - x_b)^2 + (y_a - y_b)^2}$

= ~~(20 - 20)²~~ +

$= \sqrt{(20-5)^2 + (9-4)^2}$

$= \sqrt{225 + 25}$

$= \sqrt{250}$

$D_{ML} = 5\sqrt{10}$

②