

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3

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DECLARATION OF AUTHENTICITY

DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

A handwritten signature in black ink. It starts with a stylized 'R' that has a vertical line through it, followed by the letters 'RINSLOO' in a simple, slightly slanted font.

Signature

06/08/2022

Date

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PREFACE

Firstly, I would like to thank my supervisor, Doctor Retha van Niekerk. Thank you for the time, knowledge and encouragement that you have provided every step of this journey. Without you, this would not have been possible.

Secondly, to my family – my mom, Du Toit, Lohan and Monique – thank you for all the sacrifices, support and encouragement, not only for this study but throughout all of my studies. Thank you for being there in the good and bad times. None of this would have been possible without your love and support.

Lastly, to my friends Miquette, Albert, Ilana, Gielie, Liezl, Müller, Marli, Kennith, Wesley and Dube, thank you for all the coffee and snacks, the late-night chats and the celebration after every stage of this study. I could not have asked for a better community. We will not be missing Oliver.

This study is dedicated to Violet and Scarlett Prinsloo. No matter what comes your way, your family will be there every step of the way.

ABSTRACT

Currently, there is an international call for the development of STEM-related research looking at young children (Campbell & Speldewinde, 2022:2). This call resonates with the situation in South Africa regarding STEM education. The purpose of this inquiry was to compare different types of schools (Farm schools, Township schools and Model C schools) in South Africa with regard to the teaching and learning of STEM in Grade R to 3 (Foundation Phase). This implies an in-depth inquiry aimed to determine the role of content and curriculum, the role of assessment, the role of different instructional methods and the impact of the available resources on the teaching and learning activities in STEM subjects in different schools in the North West Province of South Africa.

The inquiry utilised an international study in the guise of the Creative Little Scientists consortium (Creative Little Scientists, 2012a:5). The Creative Little Scientists consortium study aimed to map and compare existing practices for the teaching, learning and assessment of Science and Mathematics in the early years. Preliminary research done by Du Preez (2016:243) set the stage by outlining the historic development of Beginning Knowledge as a subset of the Life Skills curriculum in Grades R to 3 in South Africa. Furthermore, Du Preez (2016:243) compared the development of the Beginning Knowledge curriculum of South Africa with the international body of scholarship.

Du Preez's (2016:245) study stated that the subject matter knowledge and the pedagogical content knowledge of the Beginning Knowledge curriculum in South Africa were not yet on par with the guidelines for teaching Beginning Knowledge to learners in Grades R to 3 as described by international scholars.

A consecutive study by Van der Walt (2020:16, 94, 149) made the recommendation that in order to teach STEM effectively to learners between Grade R and 3 in South Africa, the following issues should be considered:

- That the nature (cognitive, social and emotional) of the young learner should be considered when teaching STEM. In other words, any teaching or learning should be developmentally appropriate.
- That, based on the developmental appropriateness of the young learner, one of three teaching methodologies (play, play-world and IBSE) should be utilised.
- That taking into consideration both the development nature of the learner coupled with a suitable teaching methodology, specific appropriate content domains should be selected for teaching STEM to Grades R to 3.

This inquiry aimed to complete a triptych of studies in South Africa related to STEM education in Grades R to 3 in the South African context. The historical and theoretical assumptions of the two previous studies were utilised, while the researcher proceeded towards an empirical comparative investigation, focusing on actual, real-time situations at the grassroots level in South Africa. Therefore, the inquiry was aimed at comparing the perceptions (practices and beliefs) of practising teachers with regard to STEM guidance for teaching and learning in Grades R to 3 in three different types of schools (Farm schools, Township schools and Model C schools) in South Africa.

Three major findings in terms of guidance for teachers relating to STEM education in Grades R to 3 in South Africa were determined in this inquiry. First, although the Mathematics policy document is adequate to support teachers, the document for the Science component of STEM lacks clarity for Grades R to 3. Second, the Science pedagogical content knowledge of teachers needs attention compared to the Mathematics pedagogical content knowledge of teachers. Third, attention needs to be paid to the availability of appropriate resources for both Mathematics and Science in all three types of schools.

“The dark truth that lurks is not that we teach the wrong thing, but that we teach the wrong things so well”

Key terms: Assessment, Comparative education, content and curriculum, Creative Little Scientists, Farm schools, Grades R to 3, instructional method, Mathematics, Model C schools, resources in STEM, Science, South Africa, STEM education, Township schools.

OPSOMMING

Daar is tans 'n internasionale oproep tot aksie vir die ontwikkeling van STEM-verwante navorsing wat op jong kinders fokus (Campbell & Speldewinde, 2022:2). Die oproep tot aksie is van groot belang ten opsigte van die situasie in Suid-Afrika met betrekking tot STEM-onderwys. Die doel van hierdie ondersoek was om verskillende skole (Plaasskole, Townshipskole en Model C-skole) in Suid-Afrika te vergelyk met betrekking tot die onderrig en leer van STEM tydens Graad R tot 3 (Grondslagfase). Dit impliseer 'n deurtastende ondersoek wat daarop gemik is om vas te stel wat die rol van inhoud en kurrikulum, die rol van assessering, die rol van verskillende onderrigmetodes en die impak van verskillende hulpbronne op onderwys- en leeraktiwiteite in STEM-vakke in verskillende skole in die Noordwesprovinsie in Suid-Afrika is.

Die ondersoek het gebruik gemaak van 'n internasionale studie onder die vaandel van die Creative Little Scientists-konsortium (Creative Little Scientists, 2012a:5). Die Creative Little Scientists-studie het ten doel gehad om bestaande praktyke vir die onderrig, leer en assessering van Wetenskap en Wiskunde in die vroeë jare te beskryf en te vergelyk. Voorlopige navorsing deur Du Preez (2016:243) het die weg gebaan deur die historiese ontwikkeling van Aanvangskennis as 'n onderdeel van die Lewensvaardighedekurrikulum in graad R tot 3 in Suid-Afrika af te baken. Voorts het Du Preez (2016:243) die ontwikkeling van die Aanvangskenniskurrikulum van Suid-Afrika vergelyk met die internasionale korpus van vakkundigheid.

Du Preez (2016:245) se navorsing stel dit dat die vakinhoudskennis en die pedagogiese inhoudskennis van die Aanvangskenniskurrikulum in Suid-Afrika nog nie in ooreenstemming is met die riglyne vir die onderrig van Aanvangskennis vir leerders in graad R tot 3 soos beskryf deur internasionale kenners nie.

'n Opvolgstudie deur Van der Walt (2020:16, 94, 149) het die aanbeveling gemaak dat die volgende faktore in ag geneem behoort te word ten einde STEM doeltreffend aan leerders tussen graad R en 3 in Suid-Afrika te onderrig:

- Die aard (kognitief, sosiaal en emosioneel) van die jong leerder behoort in ag geneem te word wanneer STEM onderrig word. Met ander woorde, enige onderrig of leer behoort gepas te wees in terme van die vlak van ontwikkeling.
- Gebaseer op die ontwikkelingsgepastheid van die jong leerder, behoort een van drie onderrigmetodes (spel, speelwêreld en ondersoekgebaseerde Wetenskaponderrig) gebruik te word.

- Inaggenome die ontwikkelingsaard van die leerder sowel as 'n gepaste onderrigmetodologie, behoort spesifieke gepaste inhoudsvelde geselekteer te word om STEM aan graad R tot 3 te onderrig.

Met hierdie ondersoek is daar gepoog om 'n triptiek studies in Suid-Afrika met betrekking tot STEM-onderwys in die Suid-Afrikaanse konteks van graad R tot 3 te voltooi. Die historiese en teoretiese veronderstellings van die twee voorafgaande studies is gebruik, terwyl die navorser te werk gegaan het om 'n empiriese vergelykende ondersoek te doen en op werklike, intydse situasies op grondvlak in Suid-Afrika te fokus. Dus was die ondersoek daarop gemik om die sienings (praktyke en oortuigings) van praktiserende onderwysers met betrekking tot STEM-leiding vir onderrig en leer in graad R tot 3 in verskillende tipes skole (Plaasskole, Townshipskole en Model C-skole) in Suid-Afrika te vergelyk.

Drie hoofbevindinge met betrekking tot leiding vir onderwysers ten opsigte van STEM-onderwys in graad R tot 3 in Suid-Afrika is in die studie vasgestel. Eerstens, hoewel die beleidsdokument vir Wiskunde genoegsaam is om onderwysers te ondersteun, ontbreek daar duidelikheid met betrekking tot die Wetenskapskomponent van STEM vir graad R tot 3. Tweedens verg onderwysers se pedagogiese inhoudskennis van Wetenskap aandag wanneer dit vergelyk word met hul pedagogiese inhoudskennis ten opsigte van Wiskunde. Derdens moet daar aandag gegee word aan die beskikbaarheid van gepaste hulpbronne vir sowel Wiskunde as Wetenskap in al drie tipes skole.

“The dark truth that lurks is not that we teach the wrong thing, but that we teach the wrong things so well”

Sleuteltermes: Assessering, Creative Little Scientists, Graad R tot 3, hulpbronne in STEM, inhoud en kurrikulum, Model C-skole, onderrigmetode, Plaasskole, Suid-Afrika, STEM-onderwys, Townshipskole, Vergelykende Opvoedkunde, Wiskunde en Wetenskap.

TABLE OF CONTENTS

DECLARATION OF AUTHENTICITY	I
PREFACE.....	II
ABSTRACT	III
OPSOMMING	V
CHAPTER 1 RATIONALE AND MOTIVATION FOR THE INQUIRY	1
1.1 Introduction	1
1.2 Background	3
1.3 Problem statement	6
1.4 Research aims and objectives.....	6
1.4.1 Research questions.....	7
1.4.2 Research objectives	7
1.5 Limitations	8
1.6 Chapter division	9
1.6.1 Chapter 1 – Rationale and motivation for the inquiry.....	9
1.6.2 Chapter 2 – Literature review of STEM education for young learners	9
1.6.3 Chapter 3 – Research design and methodology	9
1.6.4 Chapter 4 – Data analysis and results	10
1.6.5 Chapter 5 – Conclusion and recommendations	10
CHAPTER 2 LITERATURE REVIEW OF STEM EDUCATION FOR YOUNG LEARNERS	11
2.1 Introduction	11
2.2 Background and education system of South Africa	13

2.2.1	Background of education in South Africa	13
2.2.2	School education levels in South Africa	15
2.2.3	Types of schools in South Africa.....	16
2.2.4	Challenges in education in South Africa.....	17
2.2.4.1	The South African learners aged zero to five years	17
2.2.4.2	The Grade R to 3 (Foundation Phase) learner in South Africa	20
2.2.4.2.1	Challenges in Life Skills Grades R to 3 in South Africa	20
2.2.4.2.2	Challenges in Mathematics Grades R to 3 in South Africa	22
2.2.4.3	Achievement of South African Grade 4 learners in Science and Mathematics	24
2.2.4.4	The impact of the Covid-19 pandemic in South Africa.....	27
2.3	STEM education.....	28
2.3.1	Defining STEM (Science, Technology, Engineering and Mathematics).....	28
2.3.2	Defining STEM education	28
2.3.3	Defining STEM content and practices	31
2.4	The pedagogical phenomenon: content and curriculum.....	33
2.4.1	Defining policy, curriculum and content	33
2.4.2	Aims and objectives for Life Skills Grades R to 3 in South Africa	33
2.4.3	Aims and objectives for Mathematics Grades R to 3 in South Africa.....	34
2.4.4	Content of Life Skills Grades R to 3 in South Africa	34
2.4.5	Content of Mathematics Grades R to 3 in South Africa	36
2.4.6	Time allocation for Life Skills and Mathematics Grades R to 3 in South Africa	38

2.5	The pedagogical phenomenon: assessment.....	39
2.5.1	The purpose of assessment.....	39
2.5.2	Assessment policy for Grades R to 3 in South Africa	40
2.5.2.1	Assessment policy for Life Skills Grades R to 3 in South Africa	40
2.5.2.2	Assessment policy for Mathematics Grades R to 3 in South Africa	41
2.6	The pedagogical phenomenon: instructional method	42
2.6.1	Instructional methods in the Grade R to 3 (Foundation Phase).....	42
2.6.1.1	Play as instructional method in Grades R to 3	42
2.6.1.2	Play-worlds as an instructional method in Grades R to 3	43
2.6.1.3	Inquiry-based Science education (IBSE) as an instructional method in Grades R to 3	43
2.6.2	Policy regarding instructional methods in Grade R to 3 (Foundation Phase).....	44
2.6.2.1	Policy regarding instructional methods in Life Skills Grades R to 3 in South Africa	44
2.6.2.2	Policy regarding instructional methods in Mathematics Grades R to 3 in South Africa	44
2.7	The pedagogical phenomenon: resources	45
2.7.1	The availability and purpose of resources in STEM teaching and learning activities.....	45
2.7.2	Resources prescribed by the policy in South Africa	46
2.7.2.1	Resources prescribed for Life Skills Grades R to 3	46
2.7.2.2	Resources prescribed for Mathematics Grades R to 3.....	47
2.7.3	Challenges regarding resources in South Africa	48
2.8	Summary	52

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY	53
3.1 Introduction	53
3.2 Level 1 – The research topic.....	56
3.3 Level 2 – Problem statement	56
3.4 Level 3 – Paradigm	56
3.5 Level 4 – Conceptual framework	57
3.5.1 Content and curriculum.....	59
3.5.2 Assessment.....	59
3.5.3 Instructional method	60
3.5.4 Resources	60
3.6 Level 5 – Research design	61
3.6.1 Research method	61
3.6.1.1 Mixed method.....	61
3.6.1.2 Quantitative research method.....	62
3.6.1.3 Qualitative research method	62
3.6.2 Data collection tools.....	63
3.6.2.1 Questionnaires completed by the teachers	63
3.6.2.2 Policy documents	64
3.6.2.3 A map of the space (i.e., classroom).....	65
3.6.2.4 Individual interviews with teachers (if needed to clarify questions answered on the questionnaires)	65
3.6.2.5 Artefacts	65
3.6.3 Context of the inquiry.....	66

3.6.3.1	Population	67
3.6.3.2	Sampling	67
3.6.3.2.1	Sampling technique	67
3.6.3.2.2	Sampling size	68
3.6.4	Validity and reliability	70
3.6.5	Ethical considerations.....	71
3.6.6	Data organisation and analysis	71
3.7	Summary	72
CHAPTER 4 DATA ANALYSIS AND RESULTS		73
4.1	Keywords and abbreviations	73
4.1.1	Annual Teaching Plan.....	73
4.1.2	Artefacts	73
4.1.3	Curriculum and Assessment Policy Statement.....	74
4.1.4	Curriculum and Assessment Policy Statement (CAPS) topics	74
4.1.5	Department of Education workbook	74
4.1.6	Farm schools	74
4.1.7	Model C schools	75
4.1.8	School-based Assessment (SBA) Exemplar Booklet	75
4.1.9	Township schools	75
4.2	Introduction	75
4.3	Demographic information of the participants.....	77
4.4	Pedagogical phenomenon: content and curriculum.....	80

4.4.1	Question 10 of the adapted Creative Little Scientists questionnaire.....	80
4.4.2	Question 11 of the adapted Creative Little Scientists questionnaire.....	83
4.4.3	Question 12 of the adapted Creative Little Scientists questionnaire.....	87
4.4.4	Question 13 of the adapted Creative Little Scientists questionnaire.....	87
4.4.5	Question 14 of the adapted Creative Little Scientists questionnaire.....	91
4.4.6	Summary of the pedagogical phenomenon of connect and curriculum	95
4.5	Pedagogical phenomenon: assessment.....	96
4.5.1	Question 22 of the adapted Creative Little Scientists questionnaire.....	97
4.5.2	Question 23 of the adapted Creative Little Scientists questionnaire.....	99
4.5.3	Question 24 of the adapted Creative Little Scientists questionnaire.....	102
4.5.4	Question 25 of the adapted Creative Little Scientists questionnaire.....	111
4.5.5	Question 26 of the adapted Creative Little Scientists questionnaire.....	120
4.5.6	Question 27 of the adapted Creative Little Scientists questionnaire.....	121
4.5.7	Question 28 of the adapted Creative Little Scientists questionnaire.....	122
4.5.8	Question 29 of the adapted Creative Little Scientists questionnaire.....	123
4.5.9	Summary of the pedagogical phenomenon of assessment.....	124
4.6	Pedagogical phenomenon: instructional method	126
4.6.1	Question 15 of the adapted Creative Little Scientists questionnaire.....	126
4.6.2	Question 16 of the adapted Creative Little Scientists questionnaire.....	131
4.6.3	Question 17 of the adapted Creative Little Scientists questionnaire.....	135
4.6.4	Question 18 of the adapted Creative Little Scientists questionnaire.....	141
4.6.5	Question 19 of the adapted Creative Little Scientists questionnaire.....	148
4.6.6	Question 20 of the adapted Creative Little Scientists questionnaire.....	150

4.6.7	Question 21 of the adapted Creative Little Scientists questionnaire.....	152
4.6.8	Summary of the pedagogical phenomenon of instructional methodology.....	155
4.7	Pedagogical phenomenon: resources	157
4.7.1	Question 30 of the adapted Creative Little Scientists questionnaire.....	157
4.7.2	Question 31 of the adapted Creative Little Scientists questionnaire.....	166
4.7.3	Question 32 of the adapted Creative Little Scientists questionnaire.....	171
4.7.4	Question 33 of the adapted Creative Little Scientists questionnaire.....	178
4.7.5	Question 34 of the adapted Creative Little Scientists questionnaire.....	184
4.7.6	Question 35 of the adapted Creative Little Scientists questionnaire.....	191
4.7.7	Summary of the pedagogical phenomenon of resources	195
4.8	Summary	196
CHAPTER 5 CONCLUSION AND RECOMMENDATIONS.....		197
5.1	Motivation for the inquiry.....	197
5.2	Results and answering the research questions	198
5.3	Similarities and differences in findings between this research and the Creative Little Scientists study.....	200
5.3.1	Similarities between this research and the Creative Little Scientists study.....	200
5.3.2	Differences between this research and the Creative Little Scientists study	201
5.4	Recommendations.....	202
5.5	Extrapolations from the research findings	203
5.6	Future areas for research.....	204
5.7	Coda	204
BIBLIOGRAPHY.....		206

ADDENDUM A – CREATIVE LITTLE SCIENTISTS QUESTIONNAIRE (CREATIVE LITTLE SCIENTISTS, 2012A:153-172).	222
ADDENDUM B – ADAPTED CREATIVE LITTLE SCIENTISTS QUESTIONNAIRE.....	242
ADDENDUM C – DATA FROM ADAPTED QUESTIONNAIRE	259
ADDENDUM D – ETHICAL CLEARENCE CERTIFICATE	284
ADDENDUM E – AUTHORISATION LETTER – PROVINCIAL DEPARTMENT OF EDUCATION OR PRINCIPALS	286
ADDENDUM F – GOOD WILL PERMISSION LETTER – SCHOOL GOVERNING BODY ...	290
ADDENDUM G – INFORMED CONSENT LETTER.....	294
ADDENDUM H – MAPS OF THE SPACE.....	298
ADDENDUM I – LANGUAGE EDITOR CERTIFICATE.....	300
ADDENDUM J – TURNITIN REPORT SUMMARY	301

LIST OF TABLES

Table 2-1:	National Qualifications Framework (South African Qualification Authority, 2017:2; Vos <i>et al.</i> , 2021:66)	15
Table 2-2:	Types of schools in South Africa	16
Table 2-3:	Prescribed subjects in South Africa (Department of Basic Education, 2011a:6; 2015:9)	20
Table 2-4:	Systemic test results of Grade 3 learners in 2019 and 2021 (Department of Basic Education, 2022a)	22
Table 2-5:	Pedagogical content knowledge for teaching STEM education (Ball, Thames & Phelps, 2008:391; Shulman, 1986:9; Srikoorn <i>et al.</i> , 2018:315).....	32
Table 2-6:	Content domains of Life Skills Grades R to 3 (Department of Basic Education, 2011a:8-9).....	34
Table 2-7:	Content domains of Mathematics Grades R to 3 (Department of Basic Education, 2011b:9-10).....	36
Table 2-8:	Topics of Mathematics Grades R to 3 (Department of Basic Education, 2011b:18-34).....	37
Table 2-9:	Hours prescribed per subject for Grades R to 3 in the CAPS policy document (Department of Basic Education, 2011a:6)	39
Table 2-10:	Schools in South Africa with computer centres (Department of Basic Education, 2021b)	49
Table 2-11:	Schools in South Africa with internet access (Department of Basic Education, 2021b)	49
Table 2-12:	Schools in South Africa with libraries (Department of Basic Education, 2021b).....	50
Table 2-13:	Grade 4 South African learners' access to assets (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale <i>et al.</i> , 2022:50)	50

Table 2-14:	Grade 4 South African learners' parent engagement in early educational activities (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale <i>et al.</i> , 2022:55).....	51
Table 2-15:	Grade 4 South African learners affected by a lack of resources in schools (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale <i>et al.</i> , 2022:91).....	52
Table 3-1:	Public versus independent schools, learners and teachers in South Africa (Department of Basic Education, 2022b:1).....	66
Table 3-2:	Creative Little Scientists general selection criteria (Creative Little Scientists, 2012f:46).....	68
Table 3-3:	General selection criteria for South Africa	69
Table 3-4:	Sample sites in South Africa	69
Table 4-1:	Sample sites	76
Table 4-2:	Learners per site	79
Table 4-3:	Time spent on planning	80
Table 4-4:	Hours prescribed per subject in the CAPS policy document (Department of Basic Education, 2011a:6)	81
Table 4-5:	Hours prescribed per Life Skill learning area in CAPS (Department of Basic Education, 2011a:6)	82
Table 4-6:	Topics addressed in Science and Mathematics.....	83
Table 4-7:	Purpose of Sciences in compulsory education	87
Table 4-8:	Fostering the development of SCIENCE learning outcomes	88
Table 4-9:	Fostering the development of Mathematics learning outcomes	91
Table 4-10:	Assessment for development priorities in Science education	97
Table 4-11:	Age group priorities in Mathematics education	99
Table 4-12:	Assessment in Science	102

Table 4-13:	Extracted example of SBA assessment plan for Grade R Life Skills (Department of Basic Education, 2018c:7)	104
Table 4-14:	Extracted example of SBA rubric for Grade R Life Skills (Department of Basic Education, 2018c:11).....	105
Table 4-15:	Extracted example of SBA checklist for Grade R Life Skills (Department of Basic Education, 2018c:9).....	105
Table 4-16:	Extracted example of SBA assessment plan for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:42).....	106
Table 4-17:	Extracted example of SBA rubric for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:45).....	107
Table 4-18:	Extracted example of SBA checklist for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:43).....	107
Table 4-19:	Assessment in Mathematics.....	111
Table 4-20:	Extracted example of SBA assessment plan for Grade R Mathematics (Department of Basic Education, 2018c:6)	112
Table 4-21:	Extracted example of SBA rubric for Grade R Mathematics (Department of Basic Education, 2018c:6).....	114
Table 4-22:	Extracted example of SBA assessment plan for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:51-52).....	114
Table 4-23:	Extracted example of SBA checklist for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:53).....	117
Table 4-24:	Extracted example of SBA rubric for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:55).....	117
Table 4-25:	Using reward/praise in Science	120
Table 4-26:	Using reward or praise in Mathematics	121
Table 4-27:	Using assessment in Science to inform teaching and learning activities.....	122

Table 4-28:	Using assessment in Mathematics to inform teaching and learning activities	123
Table 4-29:	Context and approaches in Science	126
Table 4-30:	Context and approaches in Mathematics	131
Table 4-31:	Inquiry activities in Science	135
Table 4-32:	Inquiry activities in Mathematics.....	142
Table 4-33:	Approach of inquiry in the Science classroom	148
Table 4-34:	Approach of inquiry followed in the Mathematics classroom.....	150
Table 4-35:	Role of the teacher in fostering inquiry	152
Table 4-36:	Resource available in school to teach Science.....	158
Table 4-37:	Schools in South Africa with libraries (Department of Basic Education, 2021b).....	159
Table 4-38:	Schools in South Africa with computer centres (Department of Basic Education, 2021b)	161
Table 4-39:	Resources available at school to teach Mathematics	166
Table 4-40:	Using resources in Science teaching	172
Table 4-41:	Using resources in Mathematic teaching.....	178
Table 4-42:	Resources used to inform Science teaching preparation.....	184
Table 4-43:	Extract from the Annual Teaching Plan for Life Skills (Department of Basic Education, 2021c:14-22)	186
Table 4-44:	Schools in South Africa with internet access (Department of Basic Education, 2021b)	191
Table 4-45:	Resources used to inform Mathematic teaching preparation	191
Table 4-46:	Extract from the Annual Teaching Plan for Mathematics (Department of Basic Education, 2021a:3-4)	193

LIST OF FIGURES

Figure 2-1:	Learners on track or not on track according to income quintile (Giese <i>et al.</i> , 2022:16).....	18
Figure 2-2:	Learners on track or not on track according to each domain (Giese <i>et al.</i> , 2022:16).....	19
Figure 2-3:	Learners on track or not on track in Numeracy and Mathematics (Giese <i>et al.</i> , 2022:22)	19
Figure 2-4:	Question on the intermediate benchmark level, Grade 4 Science (Mullis <i>et al.</i> , 2020:118)	25
Figure 2-5:	Question on the advanced benchmark level, Grade 4 Science (Mullis <i>et al.</i> , 2020:127)	25
Figure 2-6:	Question on the low benchmark, Grade 4 Mathematics (Mullis <i>et al.</i> , 2020:44).....	26
Figure 2-7:	Question on the high benchmark, Grade 4 Mathematics (Mullis <i>et al.</i> , 2020:51).....	27
Figure 2-8:	The relationship between STEM components (Siekman & Korbel, 2016:16).....	31
Figure 3-1:	Matryoshka dolls (Anon., 2018a).....	54
Figure 3-2:	Matryoshka dolls model	54
Figure 3-3:	Structure and levels of the research methodology (Bahari, 2010; Perri & Bellamy, 2012; Bredo, 2006; Creswell, 2008:8-597; Chukwuedo, 2015:94; Ellis, Bochner, Denzin, Lincoln, Morse, Pelias & Richardson, 2008; Johnson & Christensen, 2008; Knight & Cross, 2012:41; Mackenzie & Knipe, 2006:203; Melnikovas, 2018:34-41; Muijs, 2010; Saunders, Lewis & Thornhill, 2009:108; Tashakkori & Teddlie, 2010:6; Valsiner, 2000; Yilmaz, 2013)	56
Figure 3-4:	Conceptual framework	58
Figure 4-1:	Conceptual framework	77

Figure 4-2:	Demographic information of the participants	79
Figure 4-3:	Class sizes of the participants	79
Figure 4-4:	Hours dedicated to teaching Science	81
Figure 4-5:	Hours dedicated to teaching Mathematics.....	82
Figure 4-6:	Topics addressed in Science (Life Skills – integrated subject)	85
Figure 4-7:	Topics addressed in Mathematics	86
Figure 4-8:	The importance of Sciences in compulsory education.....	87
Figure 4-9:	Fostering knowledge and an understanding of important scientific ideas	88
Figure 4-10:	Fostering an understanding of scientific investigations.....	89
Figure 4-11:	Fostering the ability to communicate in Science	90
Figure 4-12:	Fostering positive attitudes towards learning Science	90
Figure 4-13:	Fostering knowledge and an understanding of important mathematic ideas	92
Figure 4-14:	Fostering an understanding of mathematic problem solving.....	92
Figure 4-15:	Fostering the ability to communicate in Mathematics	93
Figure 4-16:	Fostering positive attitudes towards Mathematics learning.....	94
Figure 4-17:	Assessment of learners’ knowledge and understanding of scientific ideas ...	97
Figure 4-18:	Assessment of learners’ knowledge and understanding of scientific processes	98
Figure 4-19:	Assessment of learners’ attitudes towards and interest in learning Science	99
Figure 4-20:	Assessment of learners’ knowledge and understanding of Mathematic ideas	100
Figure 4-21:	Assessment of learners’ knowledge and understanding of Mathematic processes	101

Figure 4-22:	Assessment of learners' attitudes towards and interest in learning Mathematics.....	102
Figure 4-23:	Evaluating learners' artefacts in Science.....	103
Figure 4-24:	Evaluating learners' gestures or physical activity in Science	108
Figure 4-25:	Asking learners to provide verbal feedback in Science.....	109
Figure 4-26:	Using formal assessment in Science.....	110
Figure 4-27:	Evaluating learners' artefacts in Mathematics	112
Figure 4-28:	Evaluating learners' gestures or physical activity in Mathematics.....	118
Figure 4-29:	Asking learners' verbal feedback in Mathematics	119
Figure 4-30:	Using formal assessment in Mathematics	120
Figure 4-31:	Using reward or praise for innovation and creativity in Science	121
Figure 4-32:	Using reward or praise for innovation and creativity in Mathematics	122
Figure 4-33:	Using the assessment of learners to inform teaching and learning activities in Science.....	123
Figure 4-34:	Using the assessment of learners to inform teaching and learning activities in Mathematics	124
Figure 4-35:	Using different approaches in Science teaching.....	127
Figure 4-36:	Map of classical classroom arrangement	129
Figure 4-37:	Map of grouped classroom arrangement.....	129
Figure 4-38:	Using different contexts in Science teaching	130
Figure 4-39:	Using different approaches in Mathematics teaching	131
Figure 4-40:	Grade R daily programme (extracted from Department of Basic Education, 2011b:15)	134
Figure 4-41:	Using different contexts in Mathematics teaching.....	134

Figure 4-42:	Encouraging learners to observe phenomena in Science.....	135
Figure 4-43:	Fostering of skills and values (Chappell, Craft, Burnard & Cremin, 2008:269).....	136
Figure 4-44:	Encouraging learners to ask question in Science	137
Figure 4-45:	Example from Grade 2 Department of Basic Education learner workbook (Department of Basic Education, 2019:47)	138
Figure 4-46:	Encouraging learners to design and conduct investigations in Science	138
Figure 4-47:	Example from Grade 2 Department of Basic Education learner workbook (Department of Basic Education, 2019:44)	139
Figure 4-48:	Encouraging learners to use data to construct reasonable explanations in Science	140
Figure 4-49:	Encouraging learners to communicate their results in Science.....	141
Figure 4-50:	Encouraging learners to observe phenomena in Mathematics	142
Figure 4-51:	Encouraging learners to ask questions in Mathematics	143
Figure 4-52:	Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:56)	144
Figure 4-53:	Encouraging learners to design and conduct investigations in Mathematics.....	144
Figure 4-54:	Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:52)	145
Figure 4-55:	Encouraging learners to use data to construct reasonable explanations in Mathematics.....	146
Figure 4-56:	Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:18)	147
Figure 4-57:	Encouraging learners to communicate their results in Mathematics	147

Figure 4-58:	Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:10-11).....	148
Figure 4-59:	Approach of inquiry followed in the Science classroom	149
Figure 4-60:	Approach of inquiry in the Mathematics classroom.....	151
Figure 4-61:	The role of the teacher is to first demonstrate the correct way to solve a problem.....	153
Figure 4-62:	The role of the teacher is to facilitate learners' own inquiry and give them ample time to work out their own solutions.....	154
Figure 4-63:	Availability of instructional and library materials at schools for teaching Science	158
Figure 4-64:	Map of the space observation – storybooks	160
Figure 4-65:	Availability of audio-visual and digital resources at school for teaching Science	160
Figure 4-66:	Availability of equipment at school for teaching Science	161
Figure 4-67:	Materials for free play inside	163
Figure 4-68:	Availability of stationery at school for teaching Science.....	163
Figure 4-69:	Availability of stationery in different classrooms	165
Figure 4-70:	Availability of support personnel at school for teaching Science.....	165
Figure 4-71:	Availability of instructional and library materials at school for teaching Mathematics.....	166
Figure 4-72:	Availability of audio-visual and digital resources at school for teaching Mathematics.....	167
Figure 4-73:	Computer centre used as regular classroom.....	168
Figure 4-74:	Availability of equipment at school for teaching Mathematics	169
Figure 4-75:	Availability of stationery at school for teaching Mathematics	170

Figure 4-76:	Availability of support personnel at school for teaching Mathematics	171
Figure 4-77:	Using instructional and library materials when teaching Science.....	172
Figure 4-78:	Using teaching materials prepared by the teacher when teaching Science	173
Figure 4-79:	Using teaching materials prepared by a group of teachers when teaching Science	174
Figure 4-80:	Using ICT and audio-visual resources when teaching Science	175
Figure 4-81:	Using hands-on equipment and materials when teaching Science	175
Figure 4-82:	Life Skills lesson plan Grade 2	177
Figure 4-83:	Life Skills lesson plan Grade 3	178
Figure 4-84:	Using instructional and library material when teaching Mathematics	179
Figure 4-85:	Using teaching materials prepared by the teacher when teaching Mathematics.....	179
Figure 4-86:	Mathematics materials made by teachers	180
Figure 4-87:	Using teaching materials prepared by a group of teachers when teaching Mathematics.....	181
Figure 4-88:	Using ICT and audio-visual resources when teaching Mathematics	181
Figure 4-89:	Using hands-on equipment when teaching Mathematics.....	182
Figure 4-90:	Lesson plans with material for teaching and learning activities in Mathematics.....	183
Figure 4-91:	Consulting textbooks in preparing for Science teaching	184
Figure 4-92:	Consulting policy documents in preparing for Science teaching	185
Figure 4-93:	Consulting education agency websites in preparing for Science teaching ..	190
Figure 4-94:	Consulting textbooks in preparing for Mathematics teaching	192
Figure 4-95:	Consulting policy documents in preparing for Mathematics teaching.....	192

Figure 4-96:	Consulting education agency websites in preparing for Mathematics	
	teaching	194

CHAPTER 1 RATIONALE AND MOTIVATION FOR THE INQUIRY

1.1 Introduction

Globally, many challenges are experienced in the teaching and learning of the Sciences (English, 2015:4). Many countries reflect low achievement and interest among learners in STEM (Science, Technology, Engineering and Mathematics)-related subjects (European Schoolnet, 2012:6).

Furthermore, Macdonald, Tofel-Grehl and Searle (2022:352) state that:

... “the development of Science, Technology, Engineering, and Mathematics (STEM) curricula varies in quality in the early childhood years, making STEM instructions inconsistent between and within different preschool and early elementary grade levels. Given that fundamental STEM reasoning and thinking are established in early education, this lack of curricula development and the uneven manner in which it is deployed is problematic”.

This situation is also prevalent in South Africa, where the curriculum for Grades R to 3 is subdivided into three main components – Life Skills, Mathematics and Language. In the South African curriculum, three components of STEM, namely Science, Technology and Engineering, are camouflaged under the term “Beginning Knowledge”, which is a subset of the Life Skills component in the Grade R to 3 curriculum of South Africa (Du Preez, 2016:2; Van der Walt, 2020:3). In other words, when talking about STEM in the context of Grades R to 3 in South Africa, Mathematics and Science are implied.

In South Africa, we still see vast inequality in schools (Soudien, Reddy & Harvey, 2022:307). The majority of South African learners (75%) attend no-fee schools that still carry the legacy of disadvantage, providing poor-quality education with “poor infrastructure and dilapidated buildings, dangerous and unsanitary pit latrines, issues with water supply, ill-equipped teachers, shortages of learning materials, large classes, and high dropout rates” (Soudien *et al.*, 2022:307). This causes a ripple effect from the primary school years onward, as fewer than half of the learners who enter Grade 1 in these schools are appropriately aged by the time they reach Grade 4 (Moses & Van der Berg, 2017:29). Moreover, they perform at or below the lowest international benchmark for reading (Moses & Van der Berg, 2017:29).

One of the biggest problems that South Africa, within education, is facing is unqualified or underqualified teachers (Savides, 2017). Simpson (2022) reports that as of December 2021, a total of 1 575 teachers employed by the Department of Basic Education are unqualified or underqualified – 1 028 unqualified and 547 underqualified with 218 teachers as permanent

employees. “The subjects most affected include Mathematics, Sciences and Technology at all levels, and African language teaching particularly at Foundation Phase” (Savides, 2017).

Many reports on the state of Mathematics and Science in South Africa can be found (Spaull & Kotze, 2015:4). Out of the 64 countries that completed the Trends in International Mathematics and Science Study (TIMSS), South Africa obtained the third lowest achievement in both Mathematics and Science in 2019 (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Namome & Zulu, 2022:3). The sample from South Africa that completed the study consisted of 297 schools, 294 Mathematics teachers, 295 Science teachers, 11 903 Grade 4 learners and 11 720 parents (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Namome *et al.*, 2022:1). The learners obtained the following scores: 374 for Mathematics, with 400 as the low benchmark, indicating that they had basic Mathematics knowledge; 324 for Science, with 400 as the low benchmark, indicating that they had some knowledge of physical and earth Science (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Namome *et al.*, 2022:4-5).

The above information makes a strong case that intervention in Grade R to 3 (Foundation Phase education) is vital. Within the context of the 21st century, there are many factors that influence education in Africa. There is a need for the development of socially and environmentally aware citizens within the context of Mathematics, Science and Technology (Stylianidou, Glauert, Rossis & Havu-Nuutinen, 2016:209). Hands-on approaches and activities linked to learners’ everyday life must be emphasised in the implementation of a prescribed curriculum (Stylianidou *et al.*, 2016:210). Mathematics can be seen as the underlining principle and building block of the Sciences (Booth, McGinn, Barbieri, Begolli, Chang, Miller-Cotto, Young & Davenport, 2017:279). As scientific theories are always expressed in mathematical language, inadequate early Mathematics instruction can interfere with learners’ later learning and their inability to solve gatekeepers (fractions and algebra) and prevent learners from advancing in the field of Science (Booth *et al.*, 2017:279).

With the above-mentioned in mind, the researcher aimed to determine the current state of STEM education with regard to teaching and learning of the Sciences in Grade R-3. This is to provide the African continent with a comprehensive example from South Africa regarding existing and possible practices dealing with STEM as a transdisciplinary field of research for learners in Grades R, 1, 2 and 3. With the knowledge gained from this inquiry, the aim was to make a concrete contribution towards ultimately giving motivations for influencing the curriculum policy in South Africa. Furthermore, the researcher aimed to contribute to influencing in-service and pre-service training for teachers involved in teaching learners in Grades R, 1, 2 and 3.

STEM education is an instructional approach based on the idea of educating learners in four specific disciplines – Science, Technology, Engineering and Mathematics – utilising an integrated combination of subject content (Bybee, 2010:30). Through this inquiry, the researcher aimed to get a better understanding of the ways in which teachers conceptualise STEM education by investigating the following aspects: how the content and curriculum in the Sciences (including Mathematics Science, Engineering and Technology) of Grades R to 3 are conceptualised by teachers from different types of schools (and in policy) in South Africa; how the assessment of the Sciences affect teaching and learning activities in Grades R to 3 in different types of schools (and in policy) in South Africa; what methods (inquiry-based, creativity and play) are used in the teaching of the Sciences in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa; and what role the availability of resources plays in the teaching of the Sciences in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa.

Between 2011 and 2014, an international consortium, called the “Creative Little Scientists”, completed a comparative study regarding the state of STEM education in Europe. It compared nine countries (and 13 educational systems) and aimed to map and compare existing practices for the teaching, learning and assessment of Science and Mathematics in the age group of three to eight years and teacher education (Creative Little Scientists, 2012a:5).

1.2 Background

The Creative Little Scientists project was conducted by a team of experts in different aspects of education, including early childhood education, creativity in education, cognitive psychology, comparative education studies and teacher training (Creative Little Scientists, 2011:4). These experts originated from or were based in each of the nine participating countries, namely Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania and the United Kingdom (Creative Little Scientists, 2011:4). The reason for using experts from each country was to minimise the effect and implications of barriers in research, such as language, bias, traveling time and cost. By making use of experts of various nationalities in different fields of education, the study was able to provide a clear picture of existing and possible practices, together with their implications and challenges (Creative Little Scientists, 2011:4).

The main purpose of the Creative Little Scientists study was to “identify and characterise what, if any, creativity is evidenced in early Science and Mathematics (in relation both to children’s learning, and teachers’ pedagogy)” (Creative Little Scientists, 2014b:7). The study was guided by the following four research questions (Creative Little Scientists, 2014b:7-8): Research question

1: “How are the teaching, learning and assessment of Science and Mathematics in Early Years in the partner countries conceptualised by teachers and in policy? What role if any does creativity play in these?”; Research question 2: “What approaches are used in the teaching, learning and assessment of Science and Mathematics in Early Years in the partner countries? What role if any does creativity play in these?”; Research question 3: “In what ways do these approaches seek to foster young children’s learning and motivation in Science and Mathematics? How do teachers perceive their role in doing so?” and Research question 4: “How can findings emerging from analysis in relation to questions 1-3 inform the development of practice in the classroom and in teacher education (initial teacher education (ITE) and continuing professional development (CPD))?” (Creative Little Scientists, 2014b:7-8).

The Creative Little Scientists Consortium had the following key findings under each of the research questions.

Research question 1: “How are the teaching, learning and assessment of Science and Mathematics in Early Years in the partner countries conceptualised by teachers and in policy? What role if any does creativity play in these?” (Creative Little Scientists, 2014b:7). It was found that the rationale of the curriculum in nearly all of the selected countries indicated that the aim thereof was to empower learners in their role as citizens and that it emphasised Science and environmental mindfulness in their everyday lives. Teachers, however, indicated that the rationale of Science employed a more holistic approach than what was stated in policy documents (Creative Little Scientists, 2014b:14). The views of the teachers were that learning aims and objectives were the development of affective and social aspects of learning, such as increasing interest in and positive attitudes towards learning Science. However, policy documents place the emphasis of primary education on the development of knowledge and an understanding of Science and Mathematics ideas, and process skills related to scientific inquiry (Creative Little Scientists, 2014b:14).

Inquiry in teaching and learning activities was viewed by the teachers and in the policy documents as a key part of learning Science and Mathematics. Both policy and the teachers referred to the value of fostering dialogue and collaboration among learners, but both failed in providing approaches or activities that used dialogue and collaboration-enabling creativity. Preschool teachers indicated that they used open play-based learning more frequently than primary school teachers (Creative Little Scientists, 2014b:15). Formal assessment was highlighted as important for learner development by both policy and the participating teachers (Creative Little Scientists, 2014b:16). A common trend was observed that in a number of the selected countries, focus was placed on the product instead of the process in assessment (Creative Little Scientists, 2014b:17).

Research question 2: “What approaches are used in the teaching, learning and assessment of Science and Mathematics in Early Years in the partner countries? What role if any does creativity play in these?” (Creative Little Scientists, 2014b:7). The findings indicated that there was considerable potential in preschools and primary schools to foster both inquiry and creativity in teaching and learning activities in Science and Mathematics. Play and exploration activities provide learners with opportunities to foster ideas for creating. Inquiry is fostered when learners face everyday experiences and have to make decisions (Creative Little Scientists, 2014b:17). Dialogue and collaboration were observed in multiple classrooms where group work and teacher questioning were used (Creative Little Scientists, 2014b:17). Observation of primary schools indicated limited play-based activities. The findings suggested that a greater focus should be placed on the process of learners’ thinking instead of the product (Creative Little Scientists, 2014b:18). Teaching and learning activities outside of the classroom were not frequently observed, although they occurred more frequently in preschool settings. Activities in both preschools and primary schools focused more on the development of Science and Mathematics content and process skills, and rarely on creativity (Creative Little Scientists, 2014b:18). Time pressure and curriculum requirements influence teachers’ perspective of the opportunities for creativity and the use of different approaches in the teaching and learning activities of Science and Mathematics (Creative Little Scientists, 2014b:19).

Research question 3: “In what ways do these approaches seek to foster young children’s learning and motivation in Science and Mathematics? How do teachers perceive their role in doing so?” (Creative Little Scientists, 2014b:8). The findings indicated that the learners observed and made connections by drawing on prior knowledge in many of the cases. Although opportunities for fostering learners’ questioning were often observed, these opportunities were usually missed by the teachers. Engagement in social dimensions of inquiry was observed to take place more often than indicated by policy and the participants (Creative Little Scientists, 2014b:20). Learners’ inquiry skills were noted to be interconnected with their understanding of the nature of Science. The learners were also observed to show several creative attributes, including motivation and curiosity in learning activities (Creative Little Scientists, 2014b:20). The participating teachers indicated that they had not previously thought about the approaches they used in the teaching and learning activities of Science and Mathematics. They referred to the importance of fostering learners’ engagement in Science and Mathematics (Creative Little Scientists, 2014b:21).

Research question 4: “How can findings emerging from analysis in relation to questions 1-3 inform the development of practice in the classroom and in teacher education (Initial Teacher Education (ITE) and Continuing Professional Development (CPD))?” (Creative Little Scientists, 2014b:8). The findings indicated several areas that need to be addressed in teacher training that can

support and develop inquiry and creativity in the early years. The following areas were highlighted (Creative Little Scientists, 2014b:21):

- The perception of the nature of Science and Mathematics, including the purpose of preschool and primary school Science and Mathematics education.
- The characteristics and place of creativity in the teaching and learning of Science and Mathematics.
- Utilising the school grounds for teaching and learning activities in Science and Mathematics.
- Utilising different approaches that foster learners' inquiry and provide opportunities for play and exploration in both preschools and primary schools.
- Employing approaches that foster learners' agency and creativity in everyday activities.
- Utilising different forms of questioning in fostering inquiry and creativity.
- The importance of supporting learners' processing with the use of varied forms of representation, including the use of information and communication technology (ICT).
- The use of different assessment strategies that support teaching and learning in both preschools and primary schools.

In the current inquiry, the researcher aimed to recreate a part of the European study on the African continent by comparing different types of schools in South Africa in order to provide a comprehensive picture of the status of STEM education in Grades R to 3 in South Africa. Moreover, the researcher aimed to compare the perceptions of teachers with regard to STEM guidance for teaching and learning in Grades R to 3 in different types of schools in South Africa.

1.3 Problem statement

The purpose of this inquiry was to compare different types of schools (Farm schools, Township schools and Model C schools) in South Africa with regard to the teaching and learning of STEM in Grade R to 3 (Foundation Phase). This implies an in-depth inquiry that aimed to determine the role of content and curriculum, the role of assessment, the role of different instructional methods and the impact of the available resources on the teaching and learning activities in STEM subjects in different schools.

1.4 Research aims and objectives

Through this inquiry, the researcher aimed to answer the current international call for the development of STEM-related research looking at young children (see Campbell & Speldewinde, 2022:2). The researcher conducted the inquiry to reflect on the current situation regarding STEM

on the African continent. This inquiry will be the first attempt at showcasing existing practices dealing with STEM as a transdisciplinary field of research for learners in Grades R, 1, 2 and 3. In the South African curriculum, three components of STEM, namely Science, Technology and Engineering, are camouflaged under the term “Beginning Knowledge”, which is a subset of the Life Skills component in the Grade R to 3 curriculum of South Africa (Du Preez, 2016:2; Van der Walt, 2020:3). In other words, when talking about STEM in the context of Grades R to 3 in South Africa, Mathematics and Science are implied. The knowledge gained from this inquiry had as its objective to make a concrete contribution towards influencing the curriculum policy. A further contribution thereof would be towards influencing in-service and pre-service training for teachers involved in teaching learners in Grade R to 3 (Foundation Phase) in the field of STEM education. Four research questions were designed to steer the inquiry.

1.4.1 Research questions

The following research questions were formulated for the inquiry:

Research question 1: How are the content and curriculum of Mathematics and Science of Grades R to 3 conceptualised by teachers from different types of schools (and in policy) in South Africa?

Research question 2: How does the assessment of Mathematics and Science affect teaching and learning activities in Grades R to 3 in different types of schools (and in policy) in South Africa?

Research question 3: What methods (inquiry-based, creativity and play) are used in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?

Research question 4: What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?

1.4.2 Research objectives

The above-mentioned research questions had extended objectives. These research objectives were:

- to conceptualise the content and curriculum of Mathematics and Science for the Grade R to 3 (Foundation Phase) in South Africa;
- to describe the impact of assessment on the teaching and learning activities in Mathematics and Science of Grades R to 3;

- to describe the instruction methods used by teachers for Mathematics and Science in Grades R to 3 with a focus on inquiry-based learning, creativity and play;
- to identify the availability, utilisation, conceptualisation and implementation of the resources used in Mathematics and Science in Grades R to 3; and
- to propose a framework that might influence policy in order to address the conceptualisation of teachers in Grades R to 3 with regard to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of Mathematics and Science and the use of resources in both in-service and pre-service teacher development.

1.5 Limitations

Some limitations were experienced in this research. They are as follows:

- In December 2019, the Covid-19 virus broke out in the city of Wuhan, Hubei Province, China. The virus rapidly spread across the globe, leading to the global setting of regulations to attempt to limit the spread of the virus and the number of casualties (Mutanga & Abayomi, 2022:163). In South Africa, the government introduced five lockdown alert levels, each with its own set of guidelines in terms of travel permitted, types of establishments open or closed, distancing from other people and the number of people allowed in a building. Schools were closed for a period of five months in 2020, and learners were not allowed to return to school all at the same time. The North-West University also set guidelines and restrictions with regard to the in-person collection of data under each alert level of the country. All of these factors had an impact on adhering to ethical principles, obtaining permission from gatekeepers and the timeline of the collection of data.
- Due to several restrictions and the uncertainty surrounding the regulations with regard to the Covid-19 pandemic, the researcher selected eight sites in the North West Province of South Africa for this inquiry, excluding the eight other provinces of South Africa. As the collection of the datasets required multiple visits to each site, the researcher chose to collect data only in North West, as traveling between provinces was often prohibited under specific alert levels of the national lockdown.
- South Africa has a total of 24 864 schools of which only 2 154 are independent (private) schools (Department of Basic Education, 2022a:1). Thus, public schools make up 91.46% of the schools in South Africa; so, investigating these schools provides a more accurate indication of the current state of education. Therefore, the eight sites selected were public schools in North West.

- After obtaining informed consent from the participants, the researcher provided them with the questionnaire and explained what was required from them. The participants were given the opportunity to indicate if anything was unclear. Due to the length of the questionnaire (14 pages), it was left with the participants to complete in their own time, with an open line of communication with third party responsible for data collection or the researcher if they had any questions. Upon the return of the questionnaire, some of the participants indicated that they did not teach Science as a subject and thus opted not to answer the questions about Science.
- Of the eight research sites, five schools had Setswana as the medium of instruction and two had English as the medium of instruction. One of the site was a dual-medium school with English and Afrikaans. The participating teachers were mother-tongue speakers of the relevant medium of instruction. The questionnaire was only provided in English, and none of the participants indicated a preference for the questionnaire in a different language.

1.6 Chapter division

1.6.1 Chapter 1 – Rationale and motivation for the inquiry

The rationale and motivation for this inquiry are introduced in Chapter 1. The researcher also delineates the research aims and objects and indicates the limitations experienced during this inquiry.

1.6.2 Chapter 2 – Literature review of STEM education for young learners

In Chapter 2, the researcher addresses the current literature in the field of STEM education for young learners. Also included in this chapter are discussions of the education system of South Africa, STEM education and the pedagogical phenomena of content and curriculum (policy), assessment, instructional method and resources.

1.6.3 Chapter 3 – Research design and methodology

The conceptual framework that was employed to frame this inquiry is discussed in Chapter 3. An in-depth explication is provided of the data gathered utilising an existing standardised international questionnaire. The researcher also delineates the local South African context and content.

1.6.4 Chapter 4 – Data analysis and results

In Chapter 4, the data are discussed, utilising an adapted standardised questionnaire, policy documents, maps of the space, interviews and classroom artefacts. The results from the inquiry are analysed and presented to provide a comprehensive comparison of the current state of STEM in three different types of schools in South Africa.

1.6.5 Chapter 5 – Conclusion and recommendations

The final chapter concludes by sharing the key findings of this inquiry and making recommendations regarding the field of STEM education in Grade R to 3 in South Africa.

CHAPTER 2 LITERATURE REVIEW OF STEM EDUCATION FOR YOUNG LEARNERS

2.1 Introduction

Teachers are expected to teach learners how to solve the problems that they will one day face in their day-to-day work activities. These real-life problems are often interdisciplinary in nature and need to function and occur within complex systems (Wang, Charoenmuang, Knobloch & Tormoehlen, 2020). In the current economic climate, it is evident that globalisation and a decreasing interest in Science and Technology education are creating a gap of an adequate supply of scientists for a knowledge-based economy (Creative Little Scientists, 2012d:9). Consequently, a primary objective of education in Mathematics and Science should be to increase motivation for these subjects and foster positive attitudes to them (Fensham & Harlen, 1999:762). There is growing recognition of the role that Science literacy plays within society in the 21st century (Harlen, 2012:12).

In Europe, there is an emphasis on learners becoming critical citizens in a democratic society; therefore, scientific and mathematic competence is viewed as a dimension of democratic citizenship in order for these learners to be able to make informed decisions in the society to which they belong (Creative Little Scientists, 2012d:9). Education in Mathematics and Science in Grades R to 3 is needed to develop critical thinking, but these subjects can no longer be taught in a way that is meant for the pre-professional preparation for future scientists, but rather in such a way that ideas about Mathematics and Science are developed in all learners (Fensham & Harlen, 1999:755).

The aim of the study conducted by the Creative Little Scientists consortium from 2011 to 2014 was to map and compare existing practices for teacher education and the teaching, learning and assessment of Science and Mathematics in Grades R to 3 (Creative Little Scientists, 2012a:5). This comparative study was conducted by a team of experts in different aspects of education, including early childhood education, creativity in education, cognitive psychology, comparative education studies and teacher training (Creative Little Scientists, 2011:4). These experts originated from and were based in each of the nine participating countries, namely Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania and the United Kingdom (Creative Little Scientists, 2011:4). Based on the findings of Creative Little Scientists, the consortium came to the conclusion that it had to change certain perceptions of the nature and role of Science and Mathematics education (Creative Little Scientists, 2012d:13).

In the current inquiry, the researcher aimed to recreate a part of the European study that had been conducted by the Creative Little Scientists consortium on the African continent. This was done in order to provide a comprehensive understanding of STEM education on the African continent. In this inquiry, different types of schools in South Africa were compared. Arguments for using the concept of STEAM (Science, Technology, Engineering, Arts and Mathematics) instead of STEM were taken into consideration, with an emphasis on the importance of creativity and play in teaching and learning activities. The “A” in the acronym “STEAM” refers to the subject of Art, and although creativity is a part of Art, the Creative Little Scientists consortium investigated how inquiry and creativity were used in the teaching and learning activities of STEM-related subjects. For the purpose of this inquiry, this chapter includes a discussion of the background of the South African education system and STEM education. Furthermore, a discussion of each of the four pedagogical phenomena in the context of STEM education or subjects, namely content and curriculum, assessment, instructional method and resources, is presented within the context of South Africa.

The Creative Little Scientists consortium provides guidelines for conducting a literature study (Creative Little Scientists, 2011:11-19). The researcher employed these guiding principles used by Creative Little Scientists and adapted them to accommodate the uniqueness of the African situation and to design a comparative equivalent investigation on the African continent (Creative Little Scientists, 2011:11-19). The adapted principles are as follows:

- 1) A review on the **South African education system** including i) defining an education system, ii) the background of the South African education system, iii) school educational levels, iv) defining types of schools and v) current challenges of South Africa (Creative Little Scientists, 2011:18-19).
- 2) A review of **STEM education**, which includes i) defining STEM, ii) defining STEM education and iii) defining STEM content and practices.
- 3) The review of **content and curriculum (policy)** includes i) defining policy, curriculum and content, ii) aims for Science or Mathematics education in South Africa, iii) content prescribed for Science or Mathematics Grades R to 3 in South Africa and iv) time allocation for Science or Mathematics Grades R to 3 in South Africa (Creative Little Scientists, 2011:16-17).
- 4) A review on **assessment** has be done which will i) aim to define the purpose of assessment and ii) describe the policy regarding assessment in South Africa (Creative Little Scientists, 2011:16).
- 5) The review regarding **instructional method** including i) instructional methods used in the Grades R to 3 and ii) South African Policy regarding instructional method used in Grades R to 3 (Creative Little Scientists, 2011:12-15).

- 6) A review on **resources** will i) define the place of resources in teaching and learning activities, ii) resources prescribed by South African policy and iii) challenges regarding resources in South Africa (Creative Little Scientists, 2011:14).

These principles were employed to do the literature review of STEM education for young learners, which is presented in the remainder of this chapter.

2.2 Background and education system of South Africa

2.2.1 Background of education in South Africa

Formal education for white children in South Africa was established in 1652 in the Cape by the Dutch colonists. The education system was shaped by the views of these colonists. As faith formed an important part of formal education, the church had to ensure that the state established and maintained schools (Steyn, Steyn, De Waal & Wolhuter, 2011:15). The curriculum taught at schools was based on the Reformational faith. The role of the state was to distribute legislation regarding education (first official education legislation – 1714), building schools and the appointment, remuneration and dismissal of teachers (Steyn *et al.*, 2011:15; Van Niekerk, 1997:39).

In 1806, the Cape Colony came under new rule as a British colony. As the British views on education varied from the Dutch, the implementation and administration of education in South Africa changed (Van Niekerk, 1997:39). The aim of the British colonial administration was to anglicise the Dutch-Afrikaans learners, to terminate the control of education under the church and to instate education as a government function. With many residents against these aims, South Africa saw the first establishment of private schools (Steyn *et al.*, 2011:16). In 1839, the British colonial administration attempted to impose English as the sole medium of instruction in all public or state-governed schools. As a result of this, a large number of private schools were established, and after a surge of nationalism, Dutch was allowed as the medium of instruction in all public schools as of 1892. Following the Anglo-Boer war (1899-1902), the Orange Free State and the Transvaal were under British rule and again saw legislation in an effort to anglicise the Afrikaner learners (Steyn *et al.*, 2011:17). The sole medium of instruction was English, and the involvement of parents and the church in education was terminated. As many Afrikaners were not willing to send their children to schools to be taught in a foreign language with foreign values, residents established private Christian national schools, with financial support from the Netherlands (Van Niekerk, 1997:40). The Christian national schools became absorbed into public schools after 1906, when Transvaal became self-governed. This was followed by the Union of South Africa in

1910, which allowed each province (Cape Colony, Transvaal, Orange Free State and Natal) to retain its own education system. The Constitution ruled that both Dutch (later changed to Afrikaans) and English enjoyed equal rights in schools (Steyn *et al.*, 2011:17).

For black learners in South Africa, however, education has only been provided by missionaries since the end of the 18th century. The aim of the education provided by missionaries was to spread the Christian faith. Thus, missionaries established schools to which a small number (5%) of black children were admitted and where they were taught basic reading and writing skills in order to read the Bible. These schools only provided primary school education and had little financial resources, inadequate facilities and poorly trained teachers (Giliomee, 2009:195; Steyn *et al.*, 2011:17). Very few black children of school-going age attended school, and few teachers at these schools had completed Standard VI (Grade 8) (Steyn *et al.*, 2011:17).

In 1948, the National Party in power of South Africa instated rigorous segregation of races on every terrain, believing that each group (various cultural groups within the black population) would flourish within their own cultural lines. Ten self-governed states were created within the South African borders and called Homelands or Bantustans. The responsibility of black education was transferred from missionaries to the government, and thus Bantu education was established (Steyn *et al.*, 2011:17). Segregation also included the separation of communities (Vos, De Beer, Nhlapo & Kumalo, 2021:58). The segregated education approach led to inequalities in both the provision and attainment of education, which had a further major impact on employment opportunities for black people (Anderson, 2020:155). The *Bantu Education Act* 47 of 1953, as legislation for segregated education, dictated that black South Africans were not to be taught any form of Mathematics or Sciences, as it did not serve a purpose if they could not use it (Giliomee, 2009:195). As the black community saw the provision of Bantu education as inferior and as an attempt to place black people in lower-graded occupations, resistance and conflict were often seen in the second half of the 20th century. The most prominent protest against inferior education was the 1976 Soweto uprising, in which 700 students lost their lives (Steyn *et al.*, 2011:20; Vos *et al.*, 2021:58-9).

South Africa became a democratic country in 1994, and the government aimed to provide uniform education to all residents. The ten former homelands were combined into one central Department of Education that focused on all schools (public and independent) that offered education from Grades R to 12 in South Africa. Accordingly, the current education system of South Africa is built on the principles of education to all, equal opportunities for all and a strong emphasis on multicultural education (Steyn *et al.*, 2011:23; Vos *et al.*, 2021:59).

2.2.2 School education levels in South Africa

In South Africa, learners have nine years of compulsory education. Although it is not compulsory for learners to attend an educational institution before the age of four, there is a National Curriculum framework available for learners aged zero to four years (Department of Basic Education, 2015:9). This phase is referred to as the Early Childhood Development Phase. The compulsory education phases are the Grade 1 to 3 (Foundation Phase), the Intermediate Phase (Grade 4-6) and the Senior Phase (Grade 7-9). Thereafter, learners have the choice to complete Grade 10 to 12 (De Beer & Vos, 2021:100). Although Grade R (preceding Grade 1) is not yet compulsory in South Africa, learners can be admitted to this grade by the age of four if they turn five before the 30th of June in the year of admission (Steyn *et al.*, 2011:121).

The National Qualifications Framework provides a framework in which qualifications are measured to indicate the education and vocational pathways in South Africa (South African Qualification Authority, 2017). Table 2-1 below indicates the school years section for South African learners. Level 1 of the General and Further Education and Training Band is preceded by three compulsory education levels, namely the Foundation Phase, the Intermediate Phase and the Senior Phase. Each of the education levels has a set of requirements in order to procure the level.

Table 2-1: National Qualifications Framework (South African Qualification Authority, 2017:2; Vos *et al.*, 2021:66)

National Qualifications Framework				
Level	Sub-Framework and qualification types			
4	General and Further Education Training Qualifications Sub-Framework	National Certificate (Grade 12)	Occupational Certificate (level 4)	Occupational Qualifications Sub-Framework
3		Immediate Certificate (Grade 11)	Occupational Certificate (level 3)	
2		Elementary Certificate (Grade 10)	Occupational Certificate (level 2)	
1		General Certificate (End of Grade 9 – see below)	Occupational Certificate (level 1)	
General education – Compulsory education				
1	General and Further	Senior Phase	General Certificate	Compulsory

	Education Training Qualifications Sub-Framework		(Grade 9)	
			Grade 7-9	
		Intermediate Phase	Grade 4-6	Compulsory
		Foundation Phase	Grade R-3	Grade R – Not compulsory Grade 1-3 – Compulsory
		Early Childhood Development Phase	Ages 0-4	Not compulsory

2.2.3 Types of schools in South Africa

There are five types of educational institutions under the Department of Basic Education in South Africa, namely public schools, independent (private) schools, Early Childhood Development Centres, Special schools and Home-schooling institutions (Vos *et al.*, 2021:59). For this inquiry, the researcher used public schools as the study context, as they represent the larger population of schools in South Africa. Public schools in South Africa are divided into Section 20 and Section 21 schools. While Section 21 (Quintile 4 and 5) schools are financially self-managed, schools under Section 20 (Quintile 1-3) are financially dependent on the finances provided by the Provincial Department of Education (Matlhale & Erasmus, 2015:109). Farm schools, Township schools and Model C schools fall under public schools. Schools are further categorised according to a quintile category. The quintile categories are assigned according to national criteria. Quintile 1 is the poorest category, and Quintile 5 the least poor category. Quintile 1 and 2 schools are no-fee schools and may not enforce compulsory school fees (Department of Basic Education, 2010:77, 95).

In Table 2-2 below, the various types of schools in South Africa are defined. The three types of public schools used in this comparative inquiry are defined first. Although the other types of schools in South Africa were not investigated in this inquiry, it is still important to define them to provide a clear picture of the education landscape in terms of the various types of schools in the country.

Table 2-2: Types of schools in South Africa

Type of school in South Africa	Definition
Farm school	Farm schools are public schools that are situated on private property (a farm), often in rural areas (Department of Basic Education, 2010:105). Rural areas are defined as areas with lower population densities, low

	levels of economic activities and low levels of infrastructure (Department of Basic Education, 2010:100).
Township school	Township schools are situated in former settlements of the apartheid regime (Hens, Wiedemann, Raath, Stone, Renders & Craenhals, 2010:908). These schools are dependent on and fully funded by the government; learners are exempted from paying school fees, and provision is made for a feeding scheme for the learners (Rollnick & Mavhunga, 2014:357).
Model C school	Model C schools are public schools that are administrated and mostly funded by governing bodies consisting of parents and alumni (Global Media, 2017). These schools still receive a subsidy from the Provincial Department of Education in terms of Section 21 of the <i>South African Schools Act</i> 84 of 1996.
Independent (private) school	Independent (private) schools are established and maintained by private funding. This type of school must be registered by the Head of Department, National Department of Basic Education in terms of Section 46 of the <i>South African Schools Act</i> 84 of 1996.
Home-schooling institution	Home-schooling institutions refer to a parent providing his/her own child with an educational programme at home. The parent must register the child for home-school education at the Provincial Education Department (Department of Basic Education, 2010:56).
Special school	Special schools are designed to cater to the needs of learners with severe learning difficulties, physical disabilities or behavioural problems (Department of Basic Education, 2010:100).
Early Childhood Development Centres	Early Childhood Development Centres are any type of building or premises that admits and provides care for more than six learners. These centres need to be registered by the state or provincial authority and based on the registration, can accommodate babies, toddlers and young children up to age five (Department of Basic Education, 2010:37).

2.2.4 Challenges in education in South Africa

2.2.4.1 The South African learners aged zero to five years

In 2021, a research study called Thrive by Five was launched in South Africa to determine whether learners who entered Grade R in 2022 were on track with the skills and knowledge needed to enter primary school (Giese, Dawes, Tredoux, Mattes, Bridgman, Van der Berg, Schenk & Kotzé, 2022:1). The Thrive by Five report indicated that there were 1,3 million children in South Africa aged four to five years, and about 72% of these children attended some form of Early Childhood Development (ECD) centre (Giese *et al.*, 2022:1). In this study, 5 139 children aged 50 to 59 months from 1 247 ECD centres across South Africa were analysed in the following areas: gross motor development; fine motor coordination and visual motor integration; emergent numeracy and Mathematics; emergent literacy and language; and cognition and executive functioning (Giese *et al.*, 2022:4).

The findings from the Thrive to Five study indicated that two-thirds of the 1,3 million children aged four to five years were from homes with a per capita income below the poverty line. Children from these households are far less likely to attend ECD centres, and the centres these children do attend are more likely to be of inferior quality than those available to children from wealthier backgrounds (Giese *et al.*, 2022:6). The overall results from the study showed that 35% of the four- and five-year-olds in South Africa are on track with physical growth and early learning, while 49% of them are falling behind (only on track with either physical growth or early learning), and 16% of them are falling far behind in both physical growth and early learning (Giese *et al.*, 2022:13). The distribution of children who are on track and not on track according to the income quintile categories can be seen in Figure 2-1 below.

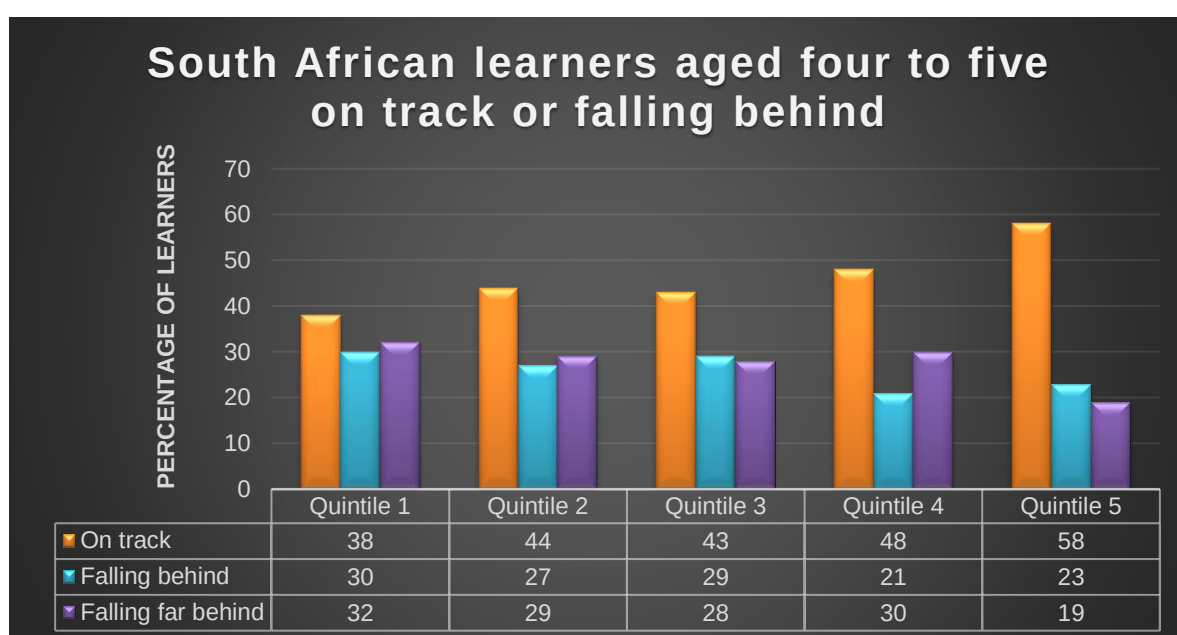


Figure 2-1: Learners on track or not on track according to income quintile (Giese *et al.*, 2022:16)

The overall results of learners aged four to five years in South Africa in each of the five domains are shown in Figure 2-2 below. The results indicated that only 34% of the learners entering Grade R in 2022 were on track with the required skills and knowledge.

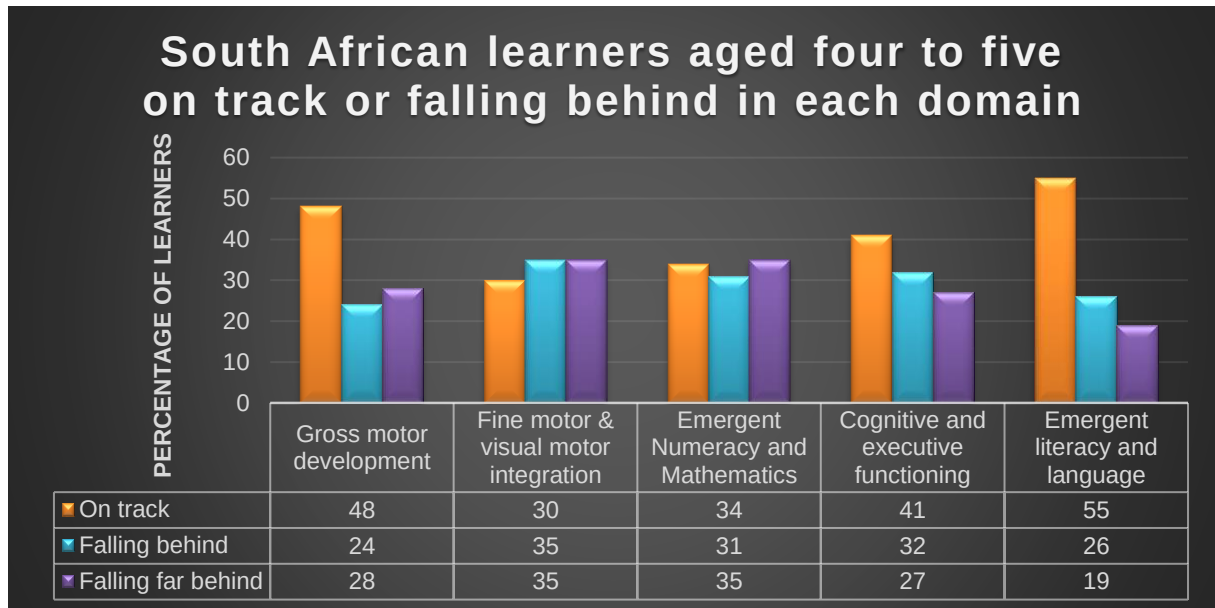


Figure 2-2: Learners on track or not on track according to each domain (Giese *et al.*, 2022:16)

The result for the Numeracy and Mathematics domain is further divided into percentages of learners per income quintile, as seen in Figure 2-3 below. The results of the study thus indicated, as seen below, that learners from the lower income quintiles were far more likely to fall into the “falling behind” category than learners from homes with wealthier incomes, especially in the domain of Numeracy and Mathematics (Giese *et al.*, 2022:22).

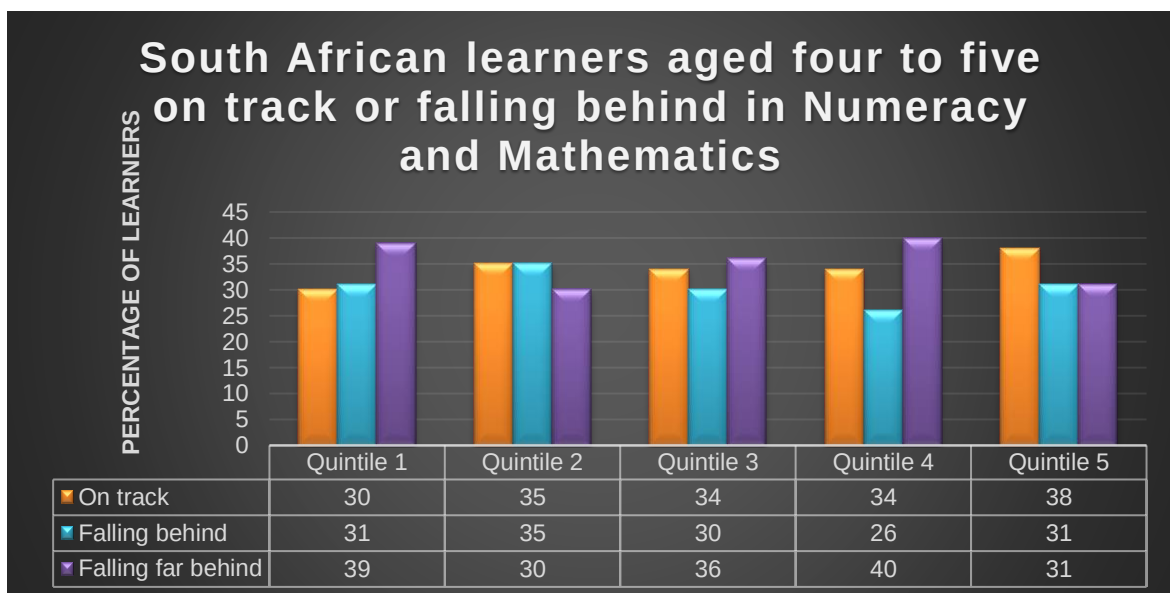


Figure 2-3: Learners on track or not on track in Numeracy and Mathematics (Giese *et al.*, 2022:22)

2.2.4.2 The Grade R to 3 (Foundation Phase) learner in South Africa

From the previous section, it is clear that 65% of learners entering the formal teaching years are already falling behind (Giese *et al.*, 2022:13). As seen in Table 2-1, a child in South Africa only enters the compulsory education phase in Grade 1. Although there is a curriculum available for children aged zero to four years and Grade R learners, these schooling years are not yet compulsory. Table 2-3 below indicates the subjects or learning areas that learners are exposed to prior to, during and after the Foundation Phase.

Table 2-3: Prescribed subjects in South Africa (Department of Basic Education, 2011a:6; 2015:9)

Phase/Grade	Compulsory	Learning areas or subjects
Age 0-4	Not compulsory	1) Well-being 2) Identity and belonging 3) Communication 4) Exploring Mathematics 5) Creativity 6) Knowledge and understanding of the world
Grade R	Not compulsory	1) Home Language 2) Mathematics 3) Life Skills
Grade 1-3	Compulsory	1) Home Language 2) First Additional Language 3) Mathematics 4) Life Skills (Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being)
Grade 4-6	Compulsory	1) Home Language 2) First Additional Language 3) Mathematics 4) Natural Sciences and Technology 5) Social Sciences 6) Life Skills (Creative Arts, Physical Education and Personal and Social Well-being)

2.2.4.2.1 Challenges in Life Skills Grades R to 3 in South Africa

In Grade R to 3 (Foundation Phase), Science forms part of an integrated subject called Life Skills. The subject of Life Skills is subdivided into four learning areas, namely Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2011a:6). Beginning Knowledge is further divided into the sub-categories of Social Science concepts, Natural Science concepts, Scientific Process skills and Technological Process skills (Department of Basic Education, 2011a:8). Personal and Social Well-being includes social health, emotional health and relationships with other people and the environment (Department of

Basic Education, 2011a:9). The learning area of Creative Arts entails visual and performing arts. Lastly, the focus of Physical Education falls on the development of gross and fine motor skills, as well as perceptual development (Department of Basic Education, 2011a:9).

Learner performance in Life Skills in Grade R to 3 (Foundation Phase) is not often reported on in South Africa. The most recent findings, as far back as 2011, state that for 2 466 Grade 3 learners from 136 schools in the Limpopo province, an overall average of 35.5% for performance was recorded (Limpopo Provincial Education Department, 2011:23).

Dixon, Janks, Botha, Earle, Poo, Oldacre, Pather and Schneider (2018:9) indicate that very little research in South Africa focus on the Life Skills subject Grade R to 3 (Foundation Phase). Krishna (2013:73) conducted a study with five Grade 1 teachers. The findings from this study showed that teachers experienced multiple challenges in terms of the content, planning, preparation and assessment of Life Skills as a Foundation Phase subject (Krishna, 2013:73). Furthermore, the teachers mentioned a lack of the resources prescribed by the Life Skills curriculum (Krishna, 2013:56). The change in the content of Life Skills after 2005 has forced in-service teachers to self-study the content areas of the subject, as teachers had not received training in them at the tertiary level (Krishna, 2013:67-69).

In a study on Life Skills by Sheldon (2014:100-101), two Grade 3 teachers participated, one from a public and one from a private school in South Africa. The conclusion was made that both these teachers deemed Life Skills as less of a priority than Mathematics and Language (Sheldon, 2014:100). Furthermore, the public school teacher was perceived as being negative towards Life Skills and did not value Beginning Knowledge, while the opposite was true for the private school teacher (Sheldon, 2014:100).

Beni, Stears and James (2017:2) indicate that Natural Science falls under the learning area of Beginning Knowledge in the subject of Life Skills for Grade R to 3 (Foundation Phase) learners. While the Life Skills curriculum for Foundation Phase learners provides guidance for teachers on what topics should be taught in each Grade, it does not provide a clear indication of how skills should be taught (Beni *et al.*, 2017:2). In their study, Beni *et al.* (2017:4) interviewed four South African teachers from each of the Foundation Phase Grades (R, 1, 2 and 3) and found that the teachers allocated time for Life Skills but not specifically to teach Science. All of the teachers used lesson plans from the Life Skills policy documents and did not develop their own. The teachers indicated that they were not completely sure what Science was and that they perceived that Science concepts were lost when the integrated teaching and learning activities were taught (Beni *et al.*, 2017:4-6). Moreover, they indicated that they avoided Science topics, as they were not

confident teaching these and experienced insecurity in their content knowledge of Science (Beni *et al.*, 2017:8).

Dixon *et al.* (2018:17) note that the Life Skills curriculum is dense and dependent on teachers drawing from specialised knowledge in multiple disciplines for effective teaching and learning. The range of disciplines found in Life Skills implicates that teachers require both depth and breadth in their knowledge of each of the four learning areas (Dixon *et al.*, 2018:19). This includes knowledge of the content, principles, skills, processes and language that have a logical progression in each of the four learning areas (Dixon *et al.*, 2018:19). Dixon *et al.* (2018:18-20) found that Foundation Phase teachers were taught to be generalist on the tertiary education level and were not prepared to provide learners with the specialist disciplinary knowledge needed to meet the demands of the Intermediate Phase.

2.2.4.2.2 Challenges in Mathematics Grades R to 3 in South Africa

In Grade R to 3 (Foundation Phase), the subject of Mathematics covers the following five content areas: numbers, operations and relationships; patterns, functions and algebra; space and shape (geometry); measurement; and data handling (statistics) (Department of Basic Education, 2011b:9-10). The South African Department of Education conducted a systemic test in the Western Cape province in October of 2021. The aim of the test was to determine the state of learner achievement in Grade 3 following the loss of teaching and learning time due to the Covid-19 pandemic. The results indicated that the Grade 3 learners of 2021 scored less than average in the subjects of Mathematics and Language compared to the Grade 3 learners of 2019, as seen in Table 2-4 below (Department of Basic Education, 2022a).

Table 2-4: Systemic test results of Grade 3 learners in 2019 and 2021 (Department of Basic Education, 2022a)

Year	Mathematics		Language	
	% of learners passing subject	Average % of group	% of learners passing subject	Average % of group
Grade 3s of 2019	58.1	54.5	44.9	44.2
Grade 3s of 2021	44.3	46.7	36.9	38.9

Machaba (2013:134) conducted a study with five Grade 3 teachers. These teachers indicated that a major challenge in Mathematics for Grade R to 3 (Foundation Phase) learners was the medium of instruction prescribed in the classroom. Policy documents stipulate that Grade R to 3 teaching and learning activities should be provided in one of the 11 official languages of South Africa (Cekiso, Meyiwa & Mashige, 2019:3). However, the teachers in Machaba's (2013:134) study

indicated that their learners were from multiple ethnical backgrounds and spoke different home languages that the teachers often did not understand. Furthermore, the teachers pointed out that mathematical concepts were difficult to teach in African languages (Machaba, 2013:134). The reason for this difficulty, according to the teachers, was that they struggled with coining new words, such as the names of basic operations, in the African languages (Machaba, 2013:134).

The findings of the above study are supported by another study conducted in 2019. Cekiso *et al.* (2019:3) show similar findings in their study including nine teachers in Grade R to 3 (Foundation Phase). These teachers stated that their teacher training had been conducted in English and had not prepared them to teach subjects such as Mathematics and Life Skills in African languages such as isiXhosa (Cekiso *et al.*, 2019:4). Furthermore, teachers noted challenges such as learners having difficulty to express themselves in Mathematics because their home language lacked the necessary vocabulary (Cekiso *et al.*, 2019:4). In addition, the teachers themselves experienced difficulty in translating Mathematics concepts into the learners' home language. The teachers indicated the same difficulties regarding language in Life Skills and pointed out that textbooks often had incorrect translations, hindering them even further (Cekiso *et al.*, 2019:6).

In a study including Grade R to 3 (Foundation Phase) teachers from 16 schools in South Africa in 2022, the teachers noted that there was a lack of continuous professional development in some of the subject areas (Bayaga & Nzuza, 2022:8). The teachers indicated that they had not been trained to support and foster learners' interest in Mathematics, including training in how to re-address errors made by learners in Mathematics content (Bayaga & Nzuza, 2022:8). Lastly, teachers noted that there was a lack of teacher training with regard to supporting learners in the process of learning Mathematics (Bayaga & Nzuza, 2022:8).

Venketsamy (2022:23) sought to understand teachers' need for instructional support in the field of Mathematics in Grade R to 3 (Foundation Phase). The study included three teachers and a department head from the same school in South Africa and a subject advisor from the local Provincial Department of Education (Venketsamy, 2022:27). The findings indicated that the teachers struggled with how to teach Mathematics content. The teachers noted that they had received teacher training at Bantu teacher colleges that did not equip them with the knowledge and skills needed to teach most of the Mathematics concepts (Venketsamy, 2022:30). Lastly, teachers indicated that although they attended workshops presented by the Department of Education, these workshops only provided them with strategies but no understanding of how teachers needed to implement these strategies in a classroom (Venketsamy, 2022:31).

2.2.4.3 Achievement of South African Grade 4 learners in Science and Mathematics

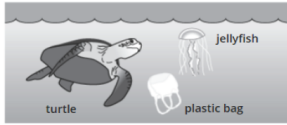
At the end of the Foundation Phase, Grade 3 learners move into the following phase of their schooling, namely the Intermediate Phase, which starts at Grade 4 in South Africa. Therefore, the statistics regarding the achievement of Grade 4 learners in South Africa are a good indicator to assist in understanding what has happened in the preceding phase. Every four years, the Trends in International Mathematics and Science Study (TIMSS) assesses Grade 4 and 8 learners around the world on their Mathematics and Science knowledge. The TIMSS study takes into account contextual factors such as the home, school and classroom environment that can have an impact on learner achievement (Mullis, Martin, Foy, Kelly & Fishbein, 2020:1). In 2019, the TIMSS study comprised of 64 countries, including South Africa (Mullis *et al.*, 2020:2). The South African Grade 4 sample consisted of 297 schools, 294 Mathematics teachers, 295 Science teachers, 11 903 learners and 11 720 parents (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Namome *et al.*, 2022:1).

The Grade 4 learners are tested in both the fields of Science and Mathematics. The Science assessment includes the domains of Life Science, Physical Science and Earth Science. The Mathematics assessment includes the domains of numbers, measurement and geometry and data (Mullis *et al.*, 2020:3). The TIMSS report indicates the average scores of all the participating countries with regard to their benchmark system (Mullis *et al.*, 2020:3). The benchmark system is divided into four sets of scores, classifying the achievement of a country in relation to the average achievement of its learners. The four sets of scores have 400 as the low benchmark, 475 as the intermediate benchmark, 550 as the high benchmark and 625 as the advanced benchmark in both Science and Mathematics (Mullis *et al.*, 2020:36, 107).

The 2019 Science assessment for Grade 4 learners consisted of 175 assessment items of varying difficulty (Mullis *et al.*, 2020:79). In Figures 2-4 and 2-5 below, examples of questions in the Science assessment for Grade 4 are provided.

Content Domain: Life Science
Cognitive Domain: Knowing
Description: States one reason why plastic objects in the ocean are dangerous for sea animals

The picture shows a turtle and jellyfish swimming in the ocean. A plastic bag is floating nearby.



Write down one reason why plastic objects in the ocean are dangerous for animals such as turtles.

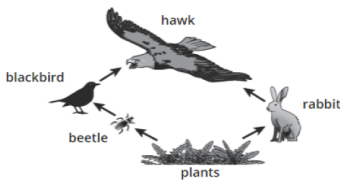
The turtle's flippers could get tangled up in the bag and make it hard for it to swim.

The answer shown illustrates the type of response that would receive full credit (1 point).

Figure 2-4: Question on the intermediate benchmark level, Grade 4 Science (Mullis *et al.*, 2020:118)

Content Domain: Life Science
Cognitive Domain: Applying
Description: Uses a food web to determine which animals are competitors

The picture below shows a food web in a forest ecosystem.



Based on what you see in the food web above, which two animals compete with each other for food?

1.
2.

The answer shown illustrates the type of response that would receive full credit (1 point).

Figure 2-5: Question on the advanced benchmark level, Grade 4 Science (Mullis *et al.*, 2020:127)

The Grade 4 learners from South Africa recorded an average score of 324 for Science (Mullis *et al.*, 2020:80). This is below the low benchmark of 400, which indicates that these learners had a limited understanding of scientific concepts and limited knowledge of foundational Science facts (Mullis *et al.*, 2020:107). From the example questions above 28% of South African learners answered the question in Figure 2-4 correctly (Mullis *et al.*, 2020:118), and 15% of South African learners answered the question in Figure 2-5 correctly (Mullis *et al.*, 2020:127).

The 2019 Mathematics assessment for Grade 4 learners consisted of 175 assessment items (Mullis *et al.*, 2020:7). The assessment comprised questions of different levels of difficulty in correspondence to the four benchmarks. Figures 2-6 and 2-7 below show examples of questions in the Mathematics assessment for Grade 4.

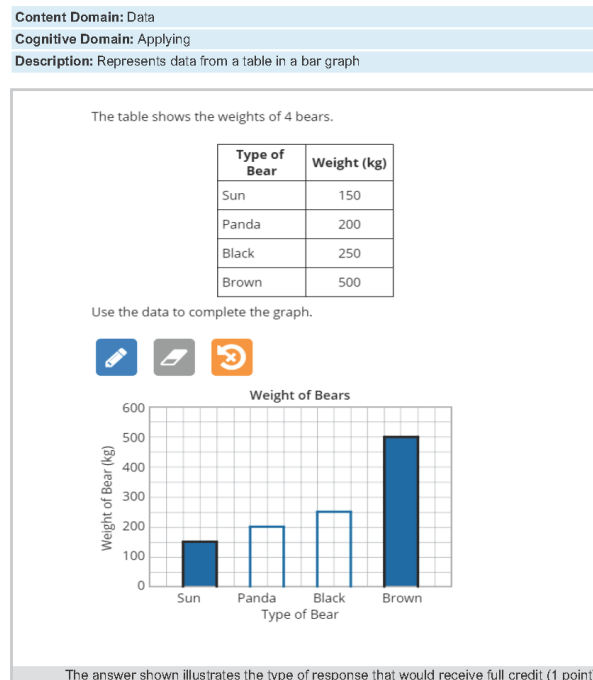


Figure 2-6: Question on the low benchmark, Grade 4 Mathematics (Mullis *et al.*, 2020:44)

Content Domain: Number
Cognitive Domain: Applying
Description: Identifies an expression that represents a situation

There were 12 liters of water in the tank.
 Ravi then poured 3 liters of water into the tank and Indira poured another 3 liters of water into the tank.



How can the amount of water in the tank be calculated?

☐ A $12 + (2 + 3)$

☐ B $(12 + 3) + (12 + 3)$

☐ C $(12 + 2) \times 3$

☒ D $12 + (2 \times 3)$

Figure 2-7: Question on the high benchmark, Grade 4 Mathematics (Mullis *et al.*, 2020:51)

The Grade 4 learners from South Africa recorded an average score of 374 for Mathematics (Mullis *et al.*, 2020:9). This is below the low benchmark of 400, which indicates that the learners had some basic Mathematics knowledge. Basic Mathematics knowledge refers to adding, subtracting, multiplication and division of one- or two-digit whole numbers, solving simple word problems and some knowledge of simple fractions and common geometric shapes (Mullis *et al.*, 2020:36). The learners from South Africa were not able to complete the questions shown above in examples (Figures 2-6 and 2-7) correctly (Mullis *et al.*, 2020:44, 51).

Although some Grade 4 learners answered the intermediate, high or advanced questions correctly in both Science and Mathematics, the overall score in both subjects is below the lowest international benchmark. This implies that in South Africa, only 37% of Grade 4 learners have basic Mathematical knowledge, and only 28% of learners have basic Science knowledge (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Namome *et al.*, 2022:5).

2.2.4.4 The impact of the Covid-19 pandemic in South Africa

The Coronavirus disease of 2019 (Covid-19) broke out in the city of Wuhan, Hubei Province, China, in December of 2019. The virus, which was transmitted through human-to-human contact, rapidly spread across the world. Each country introduced rules and regulations in order to minimise the spread of the virus and reduce the number of casualties (Mutanga & Abayomi, 2022:163). South Africa documented its first Covid-19 case on 5 March 2020. The president of South Africa, Mr. Cyril Ramaphosa, declared a national state of disaster on 15 March 2020 and implemented a national lockdown starting on 23 March 2020 (Soudien *et al.*, 2022:305). According to the rules and regulations laid down, all schools in the country were to close on 18 March 2020 and were set to be reopened in June 2020. This date was pushed back due to a spike in infections. Schools finally reopened in August of 2020 with the use of a staggered approach (Soudien *et al.*, 2022:310).

The Department of Education implemented various emergency plans during the lockdown to support learning. These included learner support programmes being broadcasted on radio and television, placing curriculum support lessons for Early Childhood Development learners online, providing learners in Grade 10 to 12 with textbooks and teacher guides, uploading updated study material on the Department of Basic Education website, making available multimedia material that is supported by mobile applications and using email and WhatsApp groups for teachers and

parents to support learners (Soudien *et al.*, 2022:309). Although multiple efforts were made by the Department of Basic Education, as seen above, 70% of the poorest South African learners had no access to technology or educational materials at home for distance learning. In no-fee schools (Quintile 1 and 2), less than half of the learners in a given classroom had access to a computer with internet at home, in contrast to 90% of the learners from wealthier schools who did have such access. Furthermore, many parents or guardians were not equipped to teach their own children (Spaull, 2020).

The staggered approach followed in August 2020 allowed schools to minimise the impact of overcrowding schoolgrounds by rotating different Grades or groups of learners from each Grade (Soudien *et al.*, 2022:310). Learners in Grade 12 were the first to return to school, having lost a total of 28 days of teaching and learning time out of 204 normal school days. The following Grade to return was Grade 7, having lost a total of 33 days. Learners in Grades R, 6 and 11 returned to school after losing 61 days. Thereafter, learners in Grades 1, 2, 3, 4, 9 and 10 returned to school, having lost a total of 76 days. Grade 5 and 8 learners returned last, after a loss of 81 teaching and learning days (Soudien *et al.*, 2022:314; Spaull, 2020). The implementation of the staggered approach was followed from the initial return of some learners to school in August 2020 up to February 2022.

2.3 STEM education

2.3.1 Defining STEM (Science, Technology, Engineering and Mathematics)

Urgency for the improvement and strengthening of Mathematics and Science education has, in recent years, been brought to the attention of the world (Breiner, Harkness, Johnson & Koehler, 2012:3). In the early 1990s, the National Science Foundation (NSF) introduced the acronym “SMET” for Science, Mathematics, Engineering and Technology, but due to the fear of the acronym being used vulgarly, “SMET” was changed to “STEM” (Breiner *et al.*, 2012:4, Siekmann & Korbel, 2016:11). According to Beiner *et al.* (2012:4), the “NSF defines STEM fields broadly, including not only the common categories of Mathematics, Natural Sciences, Engineering, and Computer and Information Sciences, but also such Social/Behavioural Sciences as Psychology, Economics, Sociology, and Political Science.”

2.3.2 Defining STEM education

Ostler (2012:29) suggests that even the concept of STEM education is not really a new idea. STEM education can be defined as “an instructional approach, **which integrates** the teaching of

Science and Mathematics disciplines through the infusion of the practices of scientific inquiry, technological and engineering design, mathematical analysis, and 21st century interdisciplinary themes and skills” (Johnson, 2013:367). Merrill and Daugherty (2009:1) define STEM education as “a standard-based, meta-discipline residing at the school level where all teachers, especially Science, Technology, Engineering and Mathematics (STEM) teachers, teach an integrated approach to teaching and learning, where discipline specific content is not divided, but addressed and treated as one dynamic, fluid study”. Although there are many definitions for STEM education, some common factors are present in each of them. For the purpose of this inquiry, the definition of STEM is as follows: “STEM education is an **integrated** approach to teaching and learning in the fields of Science, Technology, Engineering and Mathematics, while taking into consideration the effects of the prescribed content and curriculum, assessment, instructional method and resources. This means that one draws from the content and principles available in each of the individual subjects to foster a better understanding of the connectedness between the individual STEM subjects”.

Ostler (2012:29) states that the practice of integrating the content of subjects such as Mathematics and Sciences was explored by a Committee of Ten at Harvard as early as in the 1800s. The Committee of Ten (National Education Association of the United States, 1894:23) declared that a radical change was needed in the way that Mathematics was being taught. Consequently, the committee suggested that subjects that did not challenge learners mentally should be omitted from the curriculum to make space for subjects that enriched and enforced mathematic principles. Further recommendations included the introduction of Geometry in the earlier years (kindergarten) by connecting Mathematics to drawing (National Education Association of the United States, 1894:23-24).

What makes STEM education different from other teaching pedagogies are the following factors: (i) the content and practice emphasise the relationship of content across Science and Mathematics disciplines and give learners a deeper understanding of and a better framework for reasoning about interdisciplinary problems; (ii) the integrator is the practices of engineering and engineering design providing real-world, problem-solving contexts for learning, requiring them to use informed judgement to make decisions; (iii) the engineering design or engineering practices relate to relevant technology that requires Science and Mathematics concepts to solve problems; (iv) the development of 21st-century skills needed to effectively function as a citizen includes knowledge, skills and character traits; and (v) the context of instructions requires learners to work together as a team on real-world everyday problems (Bryan, Moore, Johnson & Roehrig, 2016:25).

Further attributes of STEM in education are as follows (Sullivan, Strawhacker & Bers, 2017:239-215; Zhong, Liu, Xia & Sun, 2022:1):

- Making use of real-life problems or problem-based situations.
- The development of a project-based, problem-orientated or inquiry-based learning curriculum.
- Providing learner-centred learning activities.
- Practising creative free play while using familiar educational material.
- Integrating prior knowledge from other subjects.
- Fostering high-level thinking skills, namely logical thinking, problem solving and critical thinking.
- Emphasis on the connection between the curriculum and the job market.

Siekmann and Korbel (2016:16) describe the relevance of STEM education by demonstrating how the components of STEM relate to one another. Figure 2-8 below shows how social needs are met when various STEM components are integrated with one another. For example, scientists and mathematicians create knowledge that is used by engineers to create and design new technology that, in turn, supports the needs of society and then creates a need for the pursuit of more scientific knowledge (Siekmann & Korbel, 2016:16).

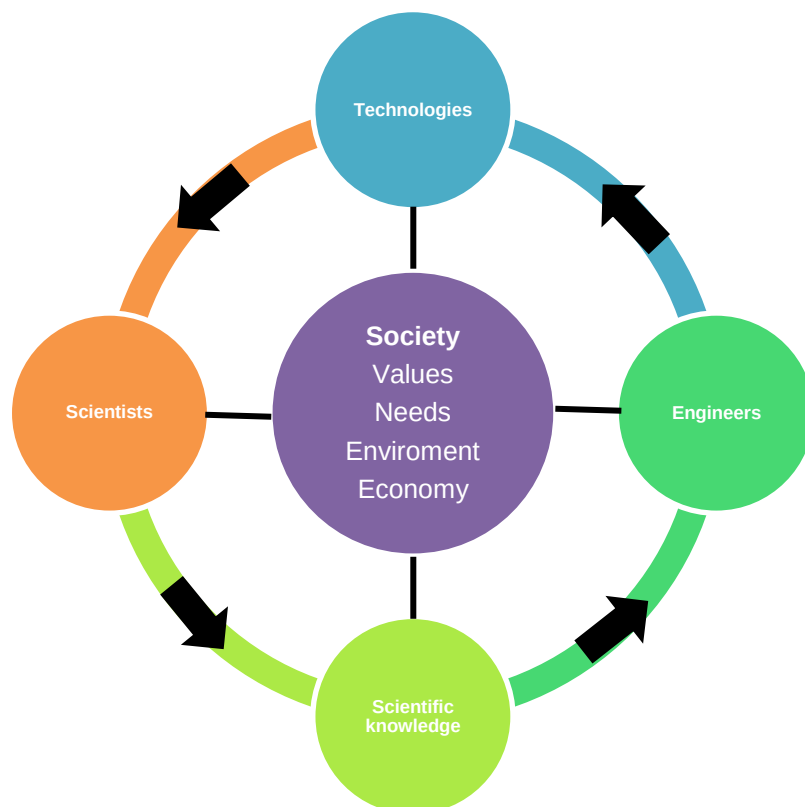


Figure 2-8: The relationship between STEM components (Siekmann & Korbel, 2016:16)

2.3.3 Defining STEM content and practices

In the 21st century, the increased use of computers and digital technology by young children has led to a pressing concern that children's natural play and creativity are not being stimulated (Sullivan *et al.*, 2017:233). Therefore, in order to promote well-rounded citizens, the promotion of creativity and innovation is emphasised when the concept of STEM education is described (Sullivan *et al.*, 2017:234; Zimmerman, 2017:1). Creativity can be defined as the mental ability to conceptualise new ideas that have not yet been thought of or to see connections in seemingly random or unrelated things (Connor, Karmokar & Whittington, 2015:39). Innovation, on the other hand, is defined as the process of making new ideas and connections into concepts that enhance value (Connor *et al.*, 2015:39).

The fields of Science, Technology, Engineering and Mathematics utilise specific content and skills (Bryan *et al.*, 2016:29). These content and skills relate to different practices, which refer to the behaviour in which a person engages when conducting a specific job, for example to investigate, design, problem-solve and build models, theories and systems (Bryan *et al.*, 2016:29). Bryan *et al.* (2016:29-31) describe four practices, namely Science inquiry, Engineering design and mathematical thinking and reasoning. Moore, Johnson, Peters-Burton and Guzey (2015:5) propose the following six key elements of integrated STEM teaching: i) motivating and engaging context; ii) engineering design challenges; iii) learning from failure; iv) standards-based Mathematic and/or Science learning objectives; v) student-centred instruction; and (f) focus on teamwork and communication.

Shulman (1986:9) states that teachers' training should provide future teachers with three types of knowledge, namely subject matter content knowledge, pedagogical content knowledge and curricular knowledge. Subject matter content knowledge refers to more than just the knowledge of the facts or concepts of a domain, but also entails an understanding of the structure of the subject matter (Shulman, 1986:9). Pedagogical content knowledge refers to the teachability of subject matter, that is, taking topics that are frequently taught in a domain and structuring them according to the most powerful analogies, illustrations, examples, explanations and demonstrations that are comprehensible to others (Shulman, 1986:9). Lastly, curricular knowledge refers to knowledge about the curriculum. The curriculum entails a full range of programmes that are designed for teaching subjects and topics at a specific level, including the instructional material and assessment. Teachers need to have knowledge of alternative

instructional methods, alternative instructional material and knowledge of the content in the preceding and later school years (Shulman, 1986:10).

Srikoom, Faikhamta and Hanuscin (2018:315) state that in STEM teaching, teachers draw on multiple specialised types of knowledge from various disciplines. Table 2-5 below indicates how teachers draw on such specialised knowledge (pedagogical content knowledge) and organise it into a subject for learners.

Table 2-5: Pedagogical content knowledge for teaching STEM education (Ball, Thames & Phelps, 2008:391; Shulman, 1986:9; Srikoom *et al.*, 2018:315)

Pedagogical content knowledge for teaching STEM education	
Component	Description
Orientations towards teaching STEM	The knowledge and perceptions of teachers regarding the purpose and aim of teaching and learning activities for STEM subjects. This refers to a) process, b) activity-driven, c) project-based science, d) inquiry and e) guided inquiry within teaching and learning.
Knowledge of STEM curriculum	Teachers need to be aware of the aim and objectives of each of the STEM concepts in each of the STEM subjects (Science, Mathematics and Technology). Furthermore, they need to know what pre-knowledge learners already have and what will be required of them. Also, teachers need to have knowledge of the curriculum of each subject and the material needed in each. This will enable teachers to be aware of different activities and materials that aid learners to meet the goals and objectives of STEM concepts.
Knowledge of learners' Understanding of STEM	The knowledge of learners' understanding of STEM subjects is directly related to a teacher's knowledge and perception of what pre-knowledge is required before a STEM lesson. This includes teachers being aware of learners' understanding of specific content, learning difficulties, motivation, diversity in ability, learning style, interest, developmental level and need.
Knowledge of instructional methods and representations for teaching STEM	Teachers' knowledge with regard to instructional methods and representation in each of the STEM subjects, keeping in mind the aims of STEM teaching.
Knowledge of assessment of STEM learning	The knowledge that teachers need to have with regard to which aspects of teaching and learning activities in STEM are significant to assess. Teachers' knowledge of different assessment strategies includes knowledge of assessment tools, approaches or activities that can be utilised during STEM activities.

2.4 The pedagogical phenomenon: content and curriculum

2.4.1 Defining policy, curriculum and content

Policy refers to a statement of intent by a country pertaining to the manner in which the needs of the residents of the country will be met (Steyn & Wolhuter, 2021:4). An education system policy is presented in multiple formats, namely acts, ordinances, government notices, white papers, regulations and rules (Steyn & Wolhuter, 2021:5). Grade R to 3 teachers in South Africa have to their disposal three key policy documents, namely the *Curriculum and Assessment Policy Statement* (CAPS), the *Annual Teaching Plan* document (ATP) and the *School-based Assessment* (SBA) document of each individual subject.

Curriculum refers to the plan of what is to be taught and learnt (Van den Akker, 2003:2). The curriculum can be interpreted in three different ways, namely the intended curriculum (what is prescribed by the policymakers or what teachers are prescribed to teach), the implemented curriculum (what is interpreted and done by teachers and learners in the classroom) and the attained curriculum (the assessment of what learners know) (Fensham & Harlen, 1999:759; Handal & Herrington, 2003:60).

Content is seen as that which learners are learning (Van den Akker, 2003:4). According to Deng and Luke (2008:7), the content of a specific subject refers to the knowledge, skills, competencies and practices related to the contexts of work, leisure or everyday life.

2.4.2 Aims and objectives for Life Skills Grades R to 3 in South Africa

The Life Skills subject of Grade R to 3 (Foundation Phase) aims to prepare learners for life by equipping them to live meaningful and successful lives in the rapidly changing society (Department of Basic Education, 2011a:8). This subject exposes learners to “a range of knowledge, skills and values that aims to strengthen learners in physical, social, personal, emotional and cognitive development” (Department of Basic Education, 2011a:8). Furthermore, the subject fosters learners’ “creative and artistic skills and knowledge through engaging in dance, music, drama and visual art activities” (Department of Basic Education, 2011a:8). The subject provides learners with “knowledge of personal health and safety” (Department of Basic Education, 2011a:8). Life Skills also aims to provide learners with an “understanding of the relationship between people and the environment whilst fostering an awareness of social relationships” (Department of Basic Education, 2011a:8). Lastly, this subject aims to expose learners to “technological processes and elementary science” (Department of Basic Education, 2011a:8).

2.4.3 Aims and objectives for Mathematics Grades R to 3 in South Africa

The subject of Mathematics of Grade R to 3 (Foundation Phase) aims to provide learners with a “critical awareness of how mathematical relationships are used in social, environmental, cultural and economic relations” (Department of Basic Education, 2011b:8). Furthermore, the aim is to foster “confidence and competence to deal with any mathematical situation without being hindered by a fear of Mathematics” (Department of Basic Education, 2011b:8). The subject aims to create opportunities that will foster “curiosity and a love of Mathematics” together with an “appreciation for the beauty and elegance of Mathematics” for learners (Department of Basic Education, 2011b:8). Learners are to be taught a “deep conceptual understanding in order to make sense of Mathematics”. Lastly, the subject aims state that the “acquisition of specific knowledge and skills [is] necessary for the application of Mathematics to physical, social and mathematical problems, the study of related subject matter (e.g. other subjects) and further study in Mathematics” (Department of Basic Education, 2011b:8).

2.4.4 Content of Life Skills Grades R to 3 in South Africa

The South African CAPS policy document for Life Skills Grade R-3 provides a breakdown of the content under each of the learning areas as seen in Table 2-6 below.

Table 2-6: Content domains of Life Skills Grades R to 3 (Department of Basic Education, 2011a:8-9)

Content of Life Skills Grades R to 3	
Life Skills learning areas	Elaboration on each learning area
Beginning Knowledge	The content of Beginning Knowledge was taken from the disciplines of Social Sciences (History and Geography), Natural Sciences and Technology. The Social Science concepts entails “conservation, cause and effect, place, adaptation, relationships and interdependence, diversity and individuality, and change” (Department of Basic Education, 2011a:8). The Natural Science concepts pertain to “life and living, energy and change, matter and materials; planet earth and beyond” (Department of Basic Education, 2011a:8). Scientific Process skills refer to “the process of enquiry which involves observing, comparing, classifying, measuring, experimenting, and communicating” and lastly, the Technological Process skills refer to “investigate, design, make, evaluate, communicate” (Department of Basic Education, 2011a:8).
Personal and Social Well-being	The content of Personal and Social Well-being refers to social health, emotional health and relationships with other people and the environment, including values and attitudes. The learning area provides learners with the skills needed to make informed, morally responsible and accountable choices regarding not only their own health but also taking into consideration the effects on the

Content of Life Skills Grades R to 3	
Life Skills learning areas	Elaboration on each learning area
	environment. The content addresses issues related to “nutrition, diseases (including HIV/AIDS), safety, violence, abuse and environmental health” (Department of Basic Education, 2011a:9).
Creative Arts	The focus of Creative Arts is divided into Visual and Performing Art. The content of Visual Arts refers to the development of sensory-motor skills and fine and gross motor coordination by using and manipulating multiple materials and utilising various art techniques. Two-dimensional (2D) work provides learners with real-world contexts, while three-dimensional (3D) work develops learners’ awareness of shape in space (Department of Basic Education, 2011a:9). The focus of Performing Art entails the use of opportunities where learners express themselves by using creative communication, dramatisation, singing, making music, dancing and the exploration of movement (Department of Basic Education, 2011a:9).
Physical Education	The focus of Physical Education is on the development of gross and fine motor skills, including the perceptual development of learners. Although there is no concrete content, learners take part in activities that involve play, movement, games and sport (Department of Basic Education, 2011a:9).

The CAPS policy document (Department of Basic Education, 2011a) provides teachers with topics that need to be taught during each of the four school terms. Teachers are encouraged by the CAPS policy document to integrate the topic into all four of the learning areas of Life Skills where possible (Department of Basic Education, 2011a:14). The ATP document provides teachers with guidance in this integration (Department of Basic Education, 2021c:1-41). Although some of the CAPS topics overlap in the Foundation Phase, there are differences in the content for Grades R to 3.

Grade R covers the topics of “me, at school, in the classroom, books, days of the weeks, my body, healthy living, summer, shapes and colours around us, festivals and special days, home, safety, my family, weather, autumn, sound, sight, touch, taste and smell, winter, transport, jobs people do, water, fruit, vegetables, dairy farming, wool farming, healthy environments, spring, birds, reptiles, dinosaurs, wild animals and sport” (Department of Basic Education, 2011a:15-21).

Grade 1 covers the topics of “me, at school, healthy habits, the weather, my family, safety at home, my body, keeping my body safe, religious days and other special days, my community, pets, manners and responsibilities, plants and seeds, food, homes, picture maps, water and the night sky” (Department of Basic Education, 2011a:30-33).

Grade 2 covers the topics of “what we need to live, everyone is special, healthy living, religious days and other special days, seasons, animals, animals and creatures that live in water, animal

homes, soil, transport, road safety, people who help us, our country, ways we communicate, life at night” (Department of Basic Education, 2011a:42-45).

Grade 3 covers the topics of “about me, feelings, health protection, keeping my body safe, rights and responsibilities, religious days and other special days, healthy eating, insects, life cycles, recycling public safety, pollution, how people lived long ago, space, products and processes, disaster and what we should do, animals and creatures that help us” (Department of Basic Education, 2011a:54-57).

The ATP policy document (Department of Basic Education, 2021c) provides teachers with a further breakdown of each CAPS topic under the four learning areas. The learning area of Personal and Social Well-being is broken down into skills and values, core concepts and knowledge, content (ensuring optimal use of Department of Education workbooks), resources and assessment. Beginning Knowledge is broken down into skills and values, knowledge (conceptual key points), CAPS content (ensuring optimal use of Department of Education workbooks, reading for meaning, resources and assessment. The Creative Arts learning area indicates prescribed activities under the categories of create in 2D, create in 3D, visual literacy, creative games and skills, improvise and interpret, and assessment. Physical Education is broken down into skills to remember, locomotor, perceptual-motor, laterality, sport and games, and assessment (Department of Basic Education, 2021c:14-22). An extracted example from the ATP policy document for Life Skills is provided in Section 4.7.5, Table 4-43 in Chapter 4.

2.4.5 Content of Mathematics Grades R to 3 in South Africa

The South African CAPS policy document for Mathematics Grades R-3 provides a clear breakdown of the content of each of the learning areas. Table 2-7 below shows an elaboration of each of the areas.

Table 2-7: Content domains of Mathematics Grades R to 3 (Department of Basic Education, 2011b:9-10)

Content Mathematics Grades R to 3	
Mathematics learning areas	Elaboration on learning area
Numbers, operations and relationships	Development of number sense that includes “the meaning of different kinds of numbers; the relationship between different kinds of numbers; the relative size of different numbers; representation of numbers in various ways; and the effect of operating with numbers” (Department of Basic Education, 2011b:9).

Patterns, functions and algebra	“Algebra is the language for investigating and communicating most of Mathematics and can be extended to the study of functions and other relationships between variables. A central part of this content area is for the learner to achieve efficient manipulative skills in the use of algebra. It also focuses on the: description of patterns and relationships through the use of symbolic expressions, graphs and tables; and identification and analysis of regularities and change in patterns, and relationships that enable learners to make predictions and solve problems” (Department of Basic Education, 2011b:9).
Space and shape (geometry)	“The study of Space and Shape improves understanding and appreciation of the pattern, precision, achievement and beauty in natural and cultural forms. It focuses on the: properties, relationships; orientations, positions; and transformations of two-dimensional shapes and three-dimensional objects” (Department of Basic Education, 2011b:10).
Measurement	“Measurement focuses on the selection and use of appropriate units, instruments and formulae to quantify characteristics of events, shapes, objects and the environment. It relates directly to the learner’s scientific, technological and economic worlds, enabling the learner to: make sensible estimates; and be alert to the reasonableness of measurements and results” (Department of Basic Education, 2011b:10).
Data handling (statistics)	<i>The policy document does not provide a breakdown of the content under Data handling</i> (Department of Basic Education, 2011b:9-10).

The CAPS policy document for Mathematics (Department of Basic Education, 2011b) provides teachers with topics that need to be taught during each of the four school terms. Although the topics remain the same under most of the content areas for Mathematics, the difficulty and number range increase by Grade. Multiple topics are repeated in Mathematics for Grades R to 3 in contrast to Life Skills where fewer topics reoccur. Table 2-8 below shows the topics under each content area and indicates whether a topic is to be taught in each of the Grades.

Table 2-8: Topics of Mathematics Grades R to 3 (Department of Basic Education, 2011b:18-34)

Topics Mathematics Grade R to 3					
Mathematics content domain	Topics	Prescribed for Grade R	Prescribed for Grade 1	Prescribed for Grade 2	Prescribed for Grade 3
Numbers, operations and relationships	Count objects	x	x	x	x
	Count forward and backward	x	x	x	x
	Number symbols and number names	x	x	x	x
	Describe, compare, order numbers	x	x	x	x
	Place value		x	x	x
	Problem-solving techniques	x	x	x	x

	Adding and subtraction	x	x	x	x
	Repeated addition leading to multiplication		x	x	x
	Division				x
	Mental Mathematics	x	x	x	x
	Fractions			x	x
Patterns, functions and algebra	Geometric patterns	x	x	x	x
	Number patterns		x	x	x
Space and shape (geometry)	Position, orientation and views	x	x	x	x
	3-D objects	x	x	x	x
	2-D objects	x	x	x	x
	Symmetry	x	x	x	x
Measurement	Time	x	x	x	x
	Length	x	x	x	x
	Mass	x	x	x	x
	Capacity	x	x	x	x
	Perimeter and area				x
Data handling (statistics)	Collect and sort objects	x	x		
	Represent sorted collection of objects	x	x		
	Discuss and report on sorted collection of objects	x	x		
	Collect and organise data		x	x	x
	Represent data		x	x	x
	Analyse and interpret data		x	x	x

The ATP policy document provides teachers with a further indication of when to teach each of the topics, along with a description of the topic, strategies, pre-knowledge required, resources and assessment (Department of Basic Education, 2021a:3-4). An extracted example from the ATP policy document for Mathematics is provided in Section 4.7.6, Table 4-46 in Chapter 4. In Mathematics, the content areas are not integrated. This is different to Life Skills, where the content is distributed among the four learning areas, namely Beginning Knowledge, Personal and Social Well-being, Creative Arts and Physical Education.

2.4.6 Time allocation for Life Skills and Mathematics Grades R to 3 in South Africa

The CAPS policy document indicates that learners in Grades R, 1 and 2 are allocated 23 hours of instructional time per week, while Grade 3 learners have a total of 25 instructional hours per

week (Department of Basic Education, 2011a:6). In Table 2-9, the prescribed hours per week per subject for each Grade are indicated.

Table 2-9: Hours prescribed per subject for Grades R to 3 in the CAPS policy document (Department of Basic Education, 2011a:6)

Prescribed instructional hours per week per Grade				
Subject	Grade R (prescribed hours per week)	Grade 1 (prescribed hours per week)	Grade 2 (prescribed hours per week)	Grade 3 (prescribed hours per week)
Home Language	10	7/8	7/8	7/8
First Additional Language	-	2/3	2/3	3/4
Mathematics	7	7	7	7
Life Skills	(6)	(6)	(6)	(7)
• Beginning Knowledge	1	1	1	2
• Creative Arts	2	2	2	2
• Physical Education	2	2	2	2
• Personal and Social Well- being	1	1	1	1
Total	23	23	23	25

2.5 The pedagogical phenomenon: assessment

2.5.1 The purpose of assessment

The purpose of the assessment of learners' performance is to provide information, establish a basis for decisions, actions and shaping the social reality (Niss, 1992:6). According to Stylianidou, Glauert, Rossis and Havu-Nuutinen (2016:204), assessment should emphasise the identification and building of the skills, attitudes, knowledge and understanding that learners bring to the classroom (Stylianidou *et al.*, 2016:204). Assessment should also encourage and support learners' active engagement in teaching and learning activities (Stylianidou *et al.*, 2016:204). Lastly, assessment should foster awareness in learners of their own progress in a subject domain (Stylianidou *et al.*, 2016:204).

"Scientific literacy" is a term that is used to express the wide-ranging and encompassing purpose of Science education (Bybee, McCrae & Laurie, 2009:865). The Organisation for Economic Co-operation and Development Committee (OECD, 2017:73) defines scientific literacy as the ability to engage with Science-related issues and ideas of Science as a reflective citizen. A scientific-

literate person is willing to engage in reasoned discourse about Science and Technology, which requires skills in explaining the phenomena scientifically, evaluating and designing scientific inquiry and interpreting data and evidence scientifically (OECD, 2017:73). The OECD thus indicates that the assessment of Science should involve assessment of the context (including personal, local or national and global issues, both current and historical, which demand some understanding of Science and Technology), knowledge (which refers to an understanding of the major facts, concepts and explanatory theories that form the basis of scientific knowledge) and competencies (including the ability to explain phenomena scientifically, evaluate and design scientific inquiry and interpret data and evidence scientifically) (Bybee *et al.*, 2009:865; OECD, 2017:73).

The OECD (2017:51) defines Mathematic literacy as an individual's capacity to formulate, employ and interpret Mathematics in multiple contexts. A mathematically literate person recognises the purpose of Mathematics in the world and is aware of the role that Mathematics plays in making well-founded decisions as a constructive, engaged and reflective citizen (OECD, 2017:51). The OECD thus indicates that the assessment of Mathematics involves assessing learners' performance regarding process, content and contexts, which indicates their ability to connect the context of a mathematical problem and solving the problem through the use of processes (Niss, 1992:3; OECD, 2017:52).

2.5.2 Assessment policy for Grades R to 3 in South Africa

The CAPS policy document prescribes that assessment takes place using four steps: generating and collecting evidence of achievement; evaluating the evidence; recording the findings; and using this information to understand and thereby assist the learner's development in order to improve the process of learning and teaching (Department of Basic Education, 2011a:66). Furthermore, the policy document states that assessment should be both informal and formal (Department of Basic Education, 2011a:66).

2.5.2.1 Assessment policy for Life Skills Grades R to 3 in South Africa

The purpose of the assessment of Life Skills in Grade R to 3 (Foundation Phase) is to assess the development of concepts, skills and values in preparation for formal assessment in the Intermediate Phase (Grades 4-6) (Department of Basic Education, 2011a:66). The assessment of learners in all four of the Life Skills learning areas ensures that learners are developing holistically (Department of Basic Education, 2011a:66).

The CAPS policy document is supported by the School Based Assessment (SBA) document (Department of Basic Education, 2018) which provides teachers with guidelines on assessing the teaching and learning activities for each subject. The assessment of Grade R learners differs from that of Grade 1, 2 and 3 learners (Department of Basic Education, 2018c:2). The Grade R teaching and learning activities are based on the principles of integration and play-based learning, and so, Grade R learners are only assessed on an informal level by observing learners' skills, values and knowledge individually or in small or large groups (Department of Basic Education, 2018c:2). Grade R learners' oral or practical work is assessed with checklists or rubrics provided in the SBA policy document for Life Skills, Mathematics and Language (Department of Basic Education, 2018c:4-40). Extracted examples from the SBA policy document for Grade R learners are provided in Section 4.5.3, Tables 4-13 to 4-15 in Chapter 4.

In Life Skills, Grades 1 to 3, the importance of continually informally and formally assessing learners' daily routine, structure and free-play activities is emphasised in assessment. Discussions, role play and demonstrations are mainly assessed in the learning areas of Creative Arts and Physical Education (Department of Basic Education, 2011a:66). The assessment of Beginning Knowledge and Physical and Social Well-being mainly comprises assessing written artefacts (Department of Basic Education, 2011a:66). The SBA policy document (Department of Basic Education, 2018b:2) states that assessment tasks designed by teachers should include content and skills from all four the learning areas and learners in Grades 1 to 3 can be assessed formally or informally, individually or in small or large groups (Department of Basic Education, 2018b:2). Learners in Grades 1 to 3 are assessed on their oral, practical or written work with checklists or rubrics provided in the SBA policy document (Department of Basic Education, 2018b:3-53). Extracted examples from the SBA policy document for Life Skills Grades 1 to 3 are provided in Section 4.5.3, Tables 4-16 to 4-18 in Chapter 4.

2.5.2.2 Assessment policy for Mathematics Grades R to 3 in South Africa

The CAPS policy document prescribes a variety of assessments (observation, oral, practical and written) to be used in Mathematics (Department of Basic Education, 2011b:485). The document notes that some learners have difficulty reading but are good in Mathematics, and some learners may not be on the required competence level of the teaching and learning medium of instruction and, therefore, need to be afforded different forms of assessment (Department of Basic Education, 2011b:486). As has already been mentioned, Grade R learners are assessed based on the principles of integration and play-based learning in all three subjects (Department of Basic Education, 2018c:2).

The SBA policy document for Grades 1 to 3 provides teachers with guidelines on assessing all five content domain of Mathematics and states whether oral, practical or written work should be assessed under each CAPS topic (Department of Basic Education, 2018a:8-73). It provides teachers with checklists and rubrics as assessment tools for assessing learners' work (Department of Basic Education, 2018a:8-9). Extracted examples from the SBA policy document for Mathematics Grades 1 to 3 are provided in Section 4.5.4, Tables 4-22 to 4-24 in Chapter 4.

2.6 The pedagogical phenomenon: instructional method

2.6.1 Instructional methods in the Grade R to 3 (Foundation Phase)

Piaget's theory indicates that a child's interactions with his or her environment are what create learning. He claims that children construct their own knowledge by giving meaning to the people, places and things in their world (Piaget, 1952:61). Sullivan *et al.* (2017:256-7) state that when a teacher wants to foster learners' engagement and creativity, the teacher's role in activities needs to be taken into account. Teachers should move within the constructionism paradigm that states that children learn more effectively when they are making things. Learners should thus be allowed to make tangible objects and test their own theories and ideas (Sullivan *et al.*, 2017:256). The teacher should be a facilitator and not an instructor during this time. In addition, teachers should provide learners with prompts, examples and demonstrations, rather than give step-by-step instructions (Sullivan *et al.*, 2017:257). Moreover, Koumara and Plakitsi (2017:106) argue that in order to create scientific knowledge or scientific inquiry, teachers need to foster scientific processes in combination with scientific reasoning and critical thinking. Teachers also need to make learners aware that there is no singular scientific method with specific steps that need to be followed in scientific inquiry (Koumara & Plakitsi, 2017:106).

Van der Walt (2020:13) states that the three main instructional methods for the early years (age 0-9) are play, play-worlds and IBSE (Inquiry-Based Science Education).

2.6.1.1 Play as instructional method in Grades R to 3

Einstein advocated that play is the highest form of research (Fleer, 2019:1257). Inquiry manifests itself within the play of young children, and play is something that is instinctive to all children (Pistorova & Slutsky, 2018:495; Pramling Samuelsson & Johansson, 2006:48). Vygotsky theorised that play is the creation of an imaginary situation, where learners take objects or actions and create new meaning within the cultural-historical conception of play (Fleer, 2019:1260). One school can serve vast contexts of different learners from different backgrounds. Learners from different contextual backgrounds will differ in the nature of their play experiences and interaction

with materials before school (Creative Little Scientists, 2012c:19). Currently, the reality in schools is that learners are passive receivers of information given by the teachers. These learners are isolated and not engaged in their own learning (Pistorova & Slutsky, 2018:497). For adults, play is seen as a leisure activity or reward after work has been completed. This mindset has been passed on to young learners at the expense of play and for the sake of scripted, didactics curricula that are implemented solely for the implementation of standardised tests (Pistorova & Slutsky, 2018:497).

When used correctly, imagination and pretend play can enhance thinking, reasoning and understanding (Goswami, 2015:5). Play then provides parents with the opportunity to introduce specific scientific and mathematical ideas and concepts to young children (Creative Little Scientists, 2012c:19). The use of physical materials can also differ in learners from only having experiences with simple materials such as paper to more complex tools such as scissors (Creative Little Scientists, 2012c:19). French (2004:140) argues that since curiosity is a natural part of young children, practical experience with materials, for example mixing the primary colours multiple times, will develop expectations and understandings related to scientific phenomena.

2.6.1.2 Play-worlds as an instructional method in Grades R to 3

Hakkarainen, Brèdikyté, Jakkula and Munter (2013:213) reveal that play-worlds derive from Vygotsky's theory on play. Educational free play takes place with minimal interference from teachers (Hakkarainen *et al.*, 2013:214). A play-world, however, aims to create an imaginary world that learners and teachers share when they interpret and dramatise a theme in the classroom (Lindqvist, 1995:7). This means that play-worlds are unique in the sense that they give the pedagogical role to the teacher, which actively supports imagination and has, in turn, been shown to develop children's imaginative play (Hakkarainen *et al.*, 2013:216). The three key features of play-worlds are learners who cross the border into a collective imaginary situation, teachers who take on the role of characters in the situation and, lastly, there is a need for a dramatic event (Van der Walt, 2020:118-119).

2.6.1.3 Inquiry-based Science education (IBSE) as an instructional method in Grades R to 3

Inquiry refers to the process that people use to make meaning of things around them (Pistorova & Slutsky, 2018:495). Young children are naturally inquisitive and construct knowledge by making use of all their senses (Pistorova & Slutsky, 2018:495). Inquiry-based learning can be defined as "the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information,

constructing models, debating with peers, and forming coherent arguments” (Linn, Davis & Bell, 2004:4). Consequently, inquiry-based learning reflects on the context of a subject being mostly about facts, without any emphasis on attitudes and thinking about a phenomenon. This type of learning requires learners to be actively involved in their own learning while the teacher merely facilitates the learning (Creative Little Scientists, 2012c:36). Thus, inquiry-based teaching and learning turn the focus from transferring knowledge to learners by asking real-world problems in which the learners then have to actively engage to find the solution and construct their own knowledge (Constantinou, Tsivitanidou & Rybska, 2018:3).

Inquiry-based learning involves the integration of other more specific teaching and learning approaches, such as anchored, hands-on, problem-based, project-based, student-centred, inductive and dialogic instruction (Constantinou *et al.*, 2018:3). Ergazaki and Zogza (2013:75) indicates the key elements of IBSE namely, experience as a key element for learning scientific concepts, meaningful understanding of the problem of inquiry, the development of basic scientific skills, such as observation, the development of reasoning or argumentation, the use of secondary resources and the promotion of collaboration.

2.6.2 Policy regarding instructional methods in Grade R to 3 (Foundation Phase)

2.6.2.1 Policy regarding instructional methods in Life Skills Grades R to 3 in South Africa

The Life Skills CAPS Grades R-3 policy document prescribes that Grade R to 3 teachers should provide routine, structured and free-play activities for learners that are enjoyable and manageable, as well as a range of resources for routine, structured and free-play activities and a well-managed, child-friendly and freely accessible environment (Department of Basic Education, 2011a:10). The ATP document encourages play as an important pedagogy for all learners Grades R to 3 in Life Skills (Department of Basic Education, 2021c:11-22). So, there is no indication in these documents of the range of methodologies as discussed by Van der Walt (2020:13). There is only an emphasis on play, but no further reference to other teaching methodologies beyond Grade R.

2.6.2.2 Policy regarding instructional methods in Mathematics Grades R to 3 in South Africa

The CAPS policy document for Mathematics Grades R to 3 provides teachers with guidelines on what activity is best taught with a specific approach. This document prescribes the use of whole-class, small-group and independent work activities for Grades R to 3 (Department of Basic

Education, 2011b:11). Whole-class activities include “mental Mathematics, consolidation of concepts and classroom management (allocation of independent activities, etc.)”, while small-group teaching includes “counting, number concept development (oral and practical activities), problem-solving (oral and practical activities), written recording, developing calculating strategies (oral and practical activities), patterns, space and shape, measurement and data handling” (Department of Basic Education, 2011b:11). Independent work is when learners practise and consolidate concepts developed during the other two types of activities (Department of Basic Education, 2011b:11).

The CAPS policy document for Mathematics further provides a structure for a daily programme for Grade R learners with a specific focus on play (Department of Basic Education, 2011b:15). The CAPS policy document prescribes that Grade R teachers should act as mediators, not facilitators, and make use of the incidental learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13). For Grades 1 to 3, the CAPS document no longer focuses on play-based learning, as in the case of Grade R. The ATP for Mathematics only prescribes whole-class activities and independent work activities (Department of Basic Education, 2021a:1).

2.7 The pedagogical phenomenon: resources

2.7.1 The availability and purpose of resources in STEM teaching and learning activities

The success of pre-service teacher training depends on the availability of resources when a teacher enters a school (Willemse, Venketsamy & Swanepoel, 2022:181). These resources include teachers (human resources), textbooks and classroom materials (physical resources, including manipulatives), time and class size (cultural resources) (Willemse *et al.*, 2022:181). When young children learn new concepts, they should start from concrete manipulatives, move to pictorial and then progress to abstract concepts (Piaget, 1952:78; Sarama & Clements, 2016:71). The use of manipulatives allows young learners to make sense of the content and aids in the recollection of covered content and problem-solving skills (Clements, 2000:45).

Olympiou and Zacharia (2011:24) reveal that the use of manipulatives in Science provides learners with a perceptual grounding that would otherwise be too abstract for them to understand. Multiple studies indicate that the use of manipulatives in Science is beneficial to learners’ learning (Gire, Carmichael, Chini, Rouinfar, Rebello, Smith & Puntambekar, 2010:937; Klahr, Triona & Williams, 2006:183; Zacharia & Constantinou, 2008:428). Klahr *et al.* (2006:183) point out that the use of concrete manipulatives in Science promotes learning, as it provides learners with

kinaesthetic involvement and increases interest, motivation and engagement. Concrete manipulatives in Science include real materials such as ramps, test tubes, plants, mechanical devices, chemicals, instruments and electrical components typically found in Science kits (Klahr *et al.*, 2006:185). Another form of manipulatives is virtual manipulatives, which refer to videos or animations on a computer-based interface that depict the same types of events that would occur when physical materials were used in the real world (Zacharia & Constantinou, 2008:426). Advantages of using virtual manipulatives in Science are that teachers do not have to procure laboratory equipment, it is safer for learners and it saves time (Gire *et al.*, 2010:937).

Several research studies have found that learners who use manipulatives in Mathematics learn more than those who do not (Johnson, 1998:96; Lamon & Huber, 1971:166; Lane, 2010:16; Moyer, 2001:177; Sowell, 1989:498). Manipulatives help learners to see and understand the concepts within their teaching and learning activities (Rust, 1999:10). Moyer (2001:186) explains that using manipulatives in Mathematics changes learners' motivation during activities, changes their attitudes towards Mathematics, assists them in developing Mathematics concepts and increases their problem-solving skills. Utilising concrete manipulatives, such as unifix cubes, pattern blocks, mirrors, tiles, plain wooden cubes, toothpicks, geoboards, recyclable materials and things one can find around the house, such as beans, allows learners to relate Mathematics to real life (Rust, 1999:10). Virtual manipulatives refer to manipulatives on a computer-based interface that represents traditional classroom manipulatives that can be manipulated or moved by utilising the computer mouse (Lane, 2010:18). Advantages of using virtual manipulatives in Mathematics are that teachers do not need to have concrete manipulatives for all the learners and there is less cleaning afterwards (Lane, 2010:19). Sarama and Clements (2016:73) point out that it is important to make use of the correct manipulatives to support learners in teaching and learning activities, as some manipulatives are more difficult for learners to work with.

2.7.2 Resources prescribed by the policy in South Africa

The CAPS and ATP policy documents of South Africa provide teachers with an indication of the resources needed to teach a subject or a specific CAPS topic (Department of Basic Education, 2011a:12; 2011b:16). Each subject has a list of resources that are specific to that subject.

2.7.2.1 Resources prescribed for Life Skills Grades R to 3

As has already been mentioned, the subject of Life Skills consists of four learning areas, namely Beginning Knowledge (under which Science content falls), Creative Arts, Physical Education and Personal and Social Well-being. Because of the nature of Life Skills the resources needed for teaching and learning activities include resources for all four the learning areas (Department of

Basic Education, 2011a:12). As teaching and learning in Grade R should be more play-based, these teachers require more resources than those teaching Grades 1 to 3. The CAPS policy document prescribes that Grade R teachers should provide learners with a safe, clean and caring environment and multiple opportunities for learners to play and explore (Department of Basic Education, 2011a:10). Teachers should also have spaces with blankets, cushions and a workspace with tables and chairs where learners can play, work and move around (Department of Basic Education, 2011a:10).

Grade R to 3 teachers are prescribed a standard list of resources to teach Life Skills in the CAPS policy document (Department of Basic Education, 2011a:12). The resources include the following items: “bean bags, ropes, hoops, balls of different sizes, balancing beams/planks/tyres, outdoor play equipment (tyres, jungle gym, climbing ropes, trees), scarves/strips of cloth, bats, containers (bowls, buckets, tins to be used as targets), skittles/bottles (as targets), hard, flat open surface, sticks, storage containers, swings, bricks, cones, balloons; dry media: wax crayons, paper, oil pastels, chalk, 2B pencils, felt-tipped pens, charcoal, sand; wet media: paint, ink, dyes, mud; brushes of different sizes; sheets of paper or scrap paper in various sizes and colours; earthenware clay, paper maché, play dough, mud; beads (glass, paper, plastic), straws, macaroni, shells, etc. for threading; recyclable materials: boxes, toilet rolls, polystyrene containers and packing materials, corks, wrapping paper, tin foil, wool, string, stones, seeds, old newspapers/magazines; glue, cardboard strips for glue applicators, scissors, pre-mixed starch; CD player, CDs, musical instruments; old clothes, utensils, containers, to be used as ‘props’ for fantasy and dramatic play; puzzles and other manipulative educational toys, bought and home made; pictures, wall charts and maps; information and story books (library); plastic lens/magnifying glass; people - older family members and invited guests” (Department of Basic Education, 2011a:12-13). For Creative Arts specifically, the following is required: “open space; musical instruments, including found and made; audio and audio-visual equipment with a range of suitable music; charts and posters; variety of props e.g. materials, balls, different sized and shaped objects, old clothes; visual stimuli for drawing and construction” (Department of Basic Education, 2011a:12-13).

The standard list of resources is expanded in the ATP policy document (Department of Basic Education, 2021c:14-22) that prescribes additional resources needed for each CAPS topic, as shown in Table 4-43.

2.7.2.2 Resources prescribed for Mathematics Grades R to 3

Play-based activities are also prescribed for Mathematics in Grade R (Department of Basic Education, 2011b:13), the same as for Life Skills. Grade R teachers are prescribed to make use

of the following activities: “fantasy play, construction with blocks, sand and water play, stories, songs, rhymes, finger games, educational toys including board games, construction and exploration activities (mass, time, capacity, measurement, etc.), imaginative play, outdoor play and playground games (wooden climbing frame or riding on the cycle track)” (Department of Basic Education, 2011b:13).

The CAPS policy document prescribes the following resources for a Mathematics classroom in Grades R to 3: “counters; large dice; a big counting frame; a height chart; big 1 - 100 and 101 - 200 number grid posters (100 - charts); different number lines (vertical and horizontal); a set of flard cards (expanding cards); play money — coins and notes; a calendar for the current year; a large analogue wall clock; a balance scale; building blocks; modelling clay; a variety of boxes of different shapes and sizes brought from home; a variety of plastic bottles and containers to describe and compare capacities; good examples of a sphere (ball), a rectangular prism (box), cube, cone, pyramid and cylinder (the teacher can make this herself); a number of plastic or cardboard squares, different rectangles, circles, different triangles all of different sizes; mathematical games, e.g. Ludo, Snakes and Ladders, jigsaw puzzles, dominoes, tangrams etc.” Essential for Grades R and 1: areas for “sand and water play, apparatus for climbing, balancing, swinging and skipping, a play-shop with items to be bought with play-money, a variety of appropriate games such as “what’s in a square?” and blocks” (Department of Basic Education, 2011b:16).

The list of resources is expanded in the ATP policy document (Department of Basic Education, 2021a:3-4) that prescribes additional resources needed for each CAPS topic, as shown in Table 4.46.

2.7.3 Challenges regarding resources in South Africa

Willemse *et al.* (2022:188) conducted a study on the support teachers need to assist learners who experience mathematical learning difficulties. They found that resources played a significant role in South African classrooms (Willemse *et al.*, 2022:188). Moreover, they found that Grade R to 3 (Foundation Phase) teachers need to utilise concrete teaching materials in particular, as these aid learners in connecting content to reality (Willemse *et al.*, 2022:188). In their study, teachers indicated a lack of especially concrete apparatus, stationery, textbooks and library facilities for STEM subjects.

According to the National Education Infrastructure Management System (NEIMS), there was a total of 23 276 public or government schools in South Africa in 2021 (Department of Basic

Education, 2021b). The NEIMS report states that only 41.8% of the public schools in South Africa had computer centres in 2021 (Department of Basic Education, 2021b). The statistics is shown in Table 2-10 below.

Table 2-10: Schools in South Africa with computer centres (Department of Basic Education, 2021b)

Availability of computer centres in South African schools (2021)			
Province	Number of schools in province	Schools with computer centres	% with computer centres
Western Cape	1 457	882	60.54
Eastern Cape	5 291	576	10.89
Northern Cape	544	288	52.94
Free State	1 084	431	39.76
KwaZulu-Natal	5 803	1 938	33.40
North West	1 471	667	45.34
Gauteng	2 074	1 662	80.14
Mpumalanga	1 718	657	38.24
Limpopo	3 834	575	15.00
Total	23 276	7 676	41.80

The NEIMS report of 2021 further states that only 29.6% of the public schools in South Africa had access to internet connectivity for teaching and learning activities, with the majority of the schools with access to the internet situated in the Western Cape province. (Department of Basic Education, 2021b). The statistics is shown below in Table 2-11.

Table 2-11: Schools in South Africa with internet access (Department of Basic Education, 2021b)

Availability of internet in South African schools					
Province	Number of schools in province	Internet connectivity for administrative purposes	% with internet connectivity for administrative purposes	Internet connectivity for teaching and learning	% with internet connectivity for teaching and learning
Western Cape	1 457	1 292	86.5	1 261	86.5
Eastern Cape	5 291	1 170	22.1	570	10.8
Northern Cape	544	408	75	215	39.5
Free State	1 084	391	36.1	303	28
KwaZulu-Natal	5 803	1 000	17.2	536	9.2
North West	1 471	650	44.2	276	18.8
Gauteng	2 074	1 441	69.5	1 327	64
Mpumalanga	1 718	241	14	99	5.8
Limpopo	3 834	345	8.9	151	3.9
Total	23 276	6 938	41.5	4 738	29.6

In 2021, only 30.41% of the schools in South Africa had libraries (Department of Basic Education, 2021b). Only 17.39% of the schools in South Africa had libraries stocked with materials (Department of Basic Education, 2021b). The statistics is shown below in Table 2-12.

Table 2-12: Schools in South Africa with libraries (Department of Basic Education, 2021b)

Availability of libraries in South African schools (2021)					
Province	Number of schools in province	Schools with libraries	% with libraries	Schools with libraries stocked with materials	% libraries stocked
Western Cape	1 457	800	54.91	449	30.82
Eastern Cape	5 291	355	6.71	215	4.06
Northern Cape	544	186	34.19	98	18.01
Free State	1 084	428	39.48	201	18.54
KwaZulu-Natal	5 803	1 408	24.26	1 005	17.32
North West	1 471	360	24.47	197	13.39
Gauteng	2 074	1 313	63.31	881	42.48
Mpumalanga	1 718	337	19.62	156	9.08
Limpopo	3 834	257	6.7	109	2.84
Total	23 276	5 444	30.41	3 311	17.39

The TIMSS report includes statistics with regard to contextual factors such as the home, school and classroom environment that can affect learner achievement (Mullis *et al.*, 2020:1). The report provides statistics regarding Grade 4 learners in South Africa. Although Grades R to 3 make up the phase preceding Grade 4, the Grade 4 statistics can provide insight into the challenges surrounding Grade R to 3 learners in the same schools or community. Table 2-13 indicates the percentage of Grade 4 learners who have access to basic, educational and digital assets at home (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale, Arends & Juan, 2022:50). From the TIMSS report, it is seen that there is a difference in access to various assets between learners from different types of schools (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:50).

Table 2-13: Grade 4 South African learners' access to assets (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:50)

Access to basic, educational and digital assets at home					
Asset type	Possession	South African %	No-fee school (Quintile 1-3) %	Fee-paying school (Quintile 4-5) %	Independent (Private school) %
Basic	Electricity	84	79	95	89
	Running tap water	66	60	79	74
	Water-flush toilets	65	53	91	90

Access to basic, educational and digital assets at home					
Educational	Hot running water from a geyser	44	34	67	66
	Child support grant	60	70	37	29
	Always/almost always speak test language at home	35	28	50	49
	Parents have post-secondary education	29	21	44	69
	Over 25 books at home	17	12	30	36
Digital	Own cell phone	67	62	78	73
	Computer or tablet	56	49	72	75
	Internet connection	37	29	56	51

The TIMSS report further provides statistics regarding the percentage of learners whose parents reported engaging in early educational activities (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:55). Table 2-14 below indicates these statistics and again shows a difference in parental engagement between learners from different types of schools.

Table 2-14: Grade 4 South African learners' parent engagement in early educational activities (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:55)

Parent engagement in early educational activities						
Activities		TIMSS international average %	South African average %	No-fee school (Quintile 1-3) %	Fee-paying school (Quintile 4-5) %	Independent (private school) %
Literacy-related activities	Read books	50	35	34	37	45
	Tell stories	50	34	31	41	45
	Play with alphabet toys	45	34	30	43	46
Numeracy-related activities	Counting rhymes and songs	41	37	33	45	43
	Play with number toys	43	35	33	41	46
	Play shape games	57	41	37	50	57
	Play with building blocks	62	34	29	45	48
	Draw shapes	49	52	50	55	53

The TIMSS report also indicates the availability of resources for Science and Mathematics that have an impact on teaching and learning activities (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:91). These statistics were generated from the feedback provided by the principals from the 297 South African participating schools. Table 2-15 below indicates the percentage of South African Grade 4 learners attending schools where a lack of resources affects the teaching and learning activities of Science and Mathematics.

Table 2-15: Grade 4 South African learners affected by a lack of resources in schools (Reddy, Winnaar, Juan, Arends, Harvey, Hannan, Isdale *et al.*, 2022:91)

Schools affected by a lack of resources			
Resources for Science	Percentage of learners affected	Resources for Mathematics	Percentage of learners affected
Teachers with specialisation in Science	49	Teachers with specialisation in Mathematics	52
Science equipment and materials for experiments	50	Concrete objects or materials to help learners understand quantities or procedures	51
Library resources relevant to Science instruction	43	Library resources relevant to Mathematics instruction	47
Computer software/applications for Science instruction	46	Library resources relevant to Mathematics instruction	46
		Calculator for Mathematics instruction	44

2.8 Summary

In this chapter, the literature underpinning the background motivation for defining the problem statement of this research was discussed. This included an overview of the education system of South Africa with a specific focus on Grade R to 3 (Foundation Phase). Furthermore, STEM, STEM education and STEM practices, which form the background of this inquiry, were defined. Lastly, each of the phenomenological pedagogies was discussed in a global and a local context.

CHAPTER 3 RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

Misconception in the use of the words “methodology” and “method” is common. **Methodology** refers to the research process as a whole. The purpose of a research methodology is to support and explain the use of specific methods in a particular study (Clough & Nutbrown, 2010:19; Perri 6 & Bellamy, 2012:1). In essence, the methodology ensures that the chosen method can lead to answering the research questions in a practical way (Clough & Nutbrown, 2010:34; Perri 6 & Bellamy, 2012:12).

The purpose of a **method** is to indicate the context under which the research was completed in order to reach the research objectives (Clough & Nutbrown, 2010:28). The chosen method then is the tool or blueprint that is used to create, collect, code, organise and analyse the data that will answer the research questions (Clough & Nutbrown, 2010:29). The method used should address all the elements of the research in order to validate the overall interrelatedness of purpose, objective and outcome as reflected in a suitable choice of a qualitative, quantitative or mixed-method approach. The different aspects within this research methodology and the different terms that this researcher used can lead to confusion unless a clear indication is given of the structure of the entire design.

For this inquiry the researcher utilised a physical model taken from the Russian culture, namely Matryoshka dolls (Anon., 2018b). With this model, the researcher aims to represent how each part of the research can stand individually but is also integrated with and held in place by the other parts of the model.



Figure 3-1: Matryoshka dolls (Anon., 2018a)

Matryoshka dolls (shown in Figure 3-1) are commonly made of wood, and the dolls decrease in size in order to fit inside each other. The outermost doll is seen as the “mother”, and the dolls inside her are all of her children, up to the smallest baby (Anon., 2018b). These dolls can stand on their own, as independent parts, but when stacked into one another, they form a whole, representing a family. If one part of the family, for example the second doll, is not put back in when stacking the dolls, the other dolls will not fit properly.

The Matryoshka doll model in Figure 3-2 below shows how the parts of the doll (the components of the research structure, as seen in Figure 3-3) are stacked together to form the whole doll (the integrated research methodology, as seen in Figure 3-3). Therefore, this Matryoshka doll model for the research represents a nested interrelationship between various parts, where the parts in themselves consist of other parts.

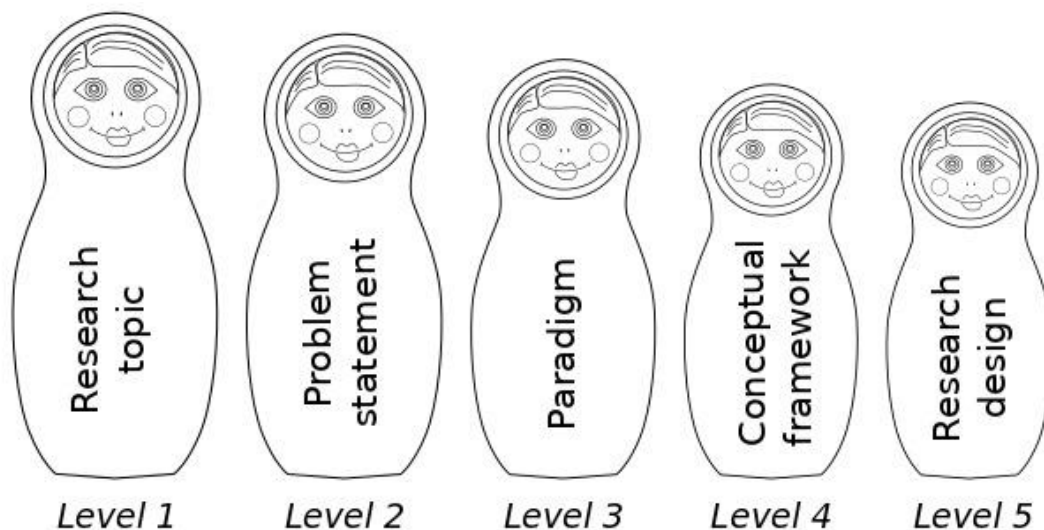


Figure 3-2: Matryoshka dolls model

So, each of the levels of this research methodology as described above is unpacked and represented in Figure 3-3.

The structure of research methodology

1. Research topic (see section 3.2)

Entails what phenomenon is to be investigated.

2. Problem statement (see section 3.3)

Describes the gap and/or the precise description of the issue that the research seeks to understand or address.

3. Paradigm (see section 3.4)

Can also be referred to as a *philosophies*. Can be defined as a shared commitment about what is to be observed or examined and therefore what counts as relevant data for answering those research questions which are deemed important, how those data should be interpreted, and what structure should we expect in satisfying answer to those questions.

Paradigms for example include: Positivism, Relativism, Realism, Constructivism, Constructionism, Subjectivity, Interpretivist, Objectivism, Pragmatism, Functionalist and Radical Structuralism, Action research, Education research design, Cultural Historical Activity Theory.

4. Conceptual framework and/or theoretical framework (see section 3.5)

Provides general approaches/designs that answers the research questions/hypotheses by building on existing research or explanations of findings.

5. Research design (see section 3.6)

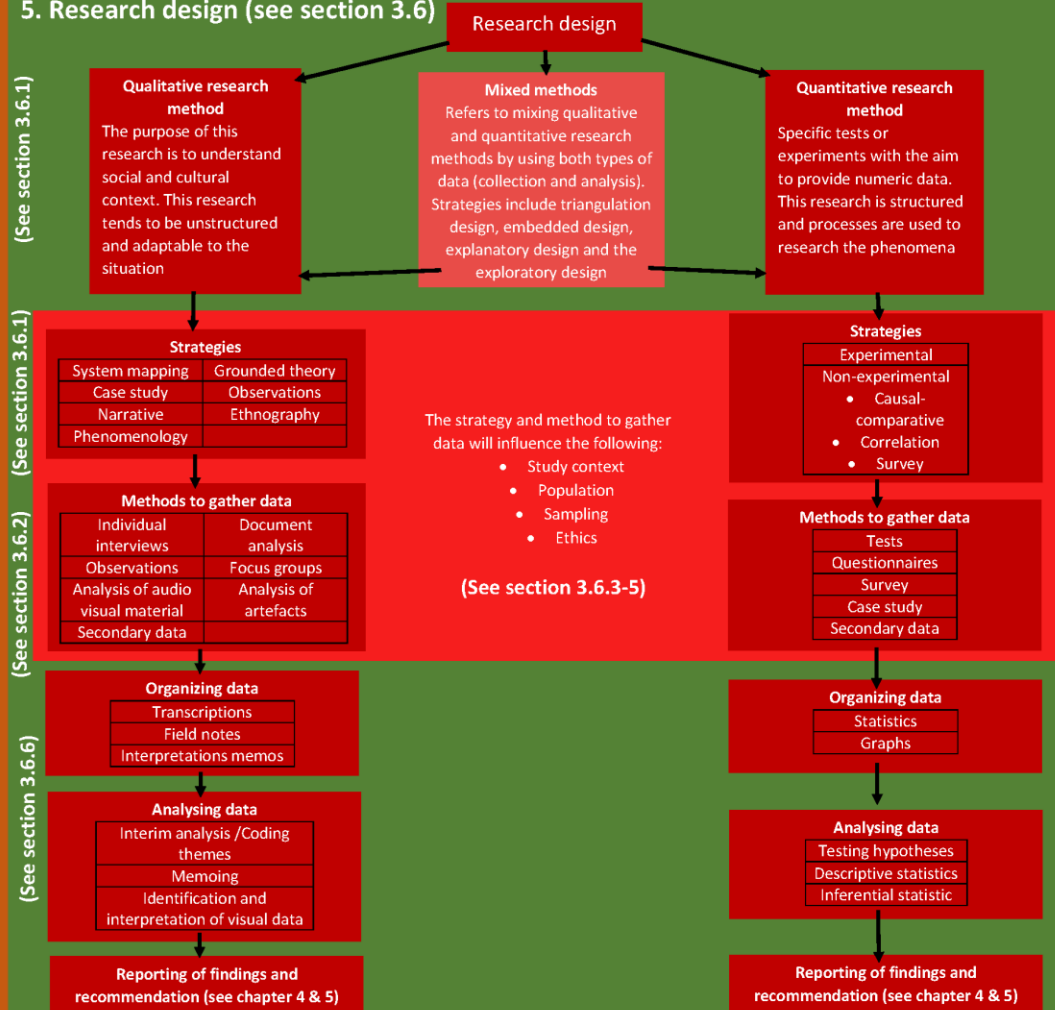


Figure 3-3: Structure and levels of the research methodology (Bahari, 2010; Perri 6 & Bellamy, 2012; Bredo, 2006; Creswell, 2008:8-597; Chukwuedo, 2015:94; Ellis, Bochner, Denzin, Lincoln, Morse, Pelias & Richardson, 2008; Johnson & Christensen, 2008; Knight & Cross, 2012:41; Mackenzie & Knipe, 2006:203; Melnikovas, 2018:34-41; Muijs, 2010; Saunders, Lewis & Thornhill, 2009:108; Tashakkori & Teddlie, 2010:6; Valsiner, 2000; Yilmaz, 2013)

3.2 Level 1 – The research topic

A research topic is an issue or problem in a specific field that needs to be investigated (Creswell, 2008:8). This inquiry dealt with the field of STEM education, with a focus on investigating the relationship between different schools in their teaching of different STEM content.

3.3 Level 2 – Problem statement

The purpose of this inquiry was to compare different types of schools (Farm schools, Township schools and Model C schools) in South Africa with regard to the teaching and learning of STEM in Grade R to 3 (Foundation Phase). This implies an in-depth inquiry aimed to determine the role of content and curriculum, the role of assessment, the role of different instructional methods and the impact of available resources on the teaching and learning activities in STEM subjects in different schools.

3.4 Level 3 – Paradigm

A paradigm represents a researcher's perception of the world and his or her own relation to the world (Waring, 2017:17). For this inquiry, the researcher used the Cultural-Historical Activity Theory (CHAT) paradigm. CHAT offers a multidimensional, systemic approach that includes the reflective research of humans and their cultural values and resources (Plakitsi, 2013:17-20, Foot, 2014:329-30). The CHAT Paradigm is built on the following principles: i) humans learn by doing in a social environment, ii) humans develop different tools to facilitate learning and communication, and iii) community is the starting point of learning and interpretation of the world (Vygotsky, 1980). This theory seeks to understand the relationship between the actions that individuals take during human consciousness and engagement with the world (Roth & Lee, 2007:201).

In other words, the CHAT paradigm can be seen as an active model that develops through collective learning actions and responses, thereby enabling a multi-faceted analysis of the interactions between professionals and their clients (Foot, 2014:30). This paradigm allowed the researcher to take the stand that the young child forms concepts regarding Science and Mathematics by participating in social activities within the child's environment (see Fragkiadaki, Flee & Ravanis, 2021:3). Consequently, this theory allowed the researcher to engage with the participants in different social settings and contexts and to explore how the participants experienced the natural world (Fragkiadaki *et al.*, 2021:3). The field of cultural-historical early childhood Science education research is limited, but has found that i) play and creativity are crucial in the development of scientific reasoning for young children, ii) children interact and engage in multiple ways with their realities, and iii) the way in which teachers engage or facilitate during teaching and learning activities is of great importance (Fragkiadaki *et al.*, 2021:3).

3.5 Level 4 – Conceptual framework

Both Clough and Nutbrown (2010:104) and Perri 6 and Bellamy (2012:300) indicate that a conceptual framework enables a researcher to identify interlocking key concepts or words that can be used in the search for literature that leads to a better understanding of the research questions. The Creative Little Scientists programme identified pedagogical synergies between inquiry-based education and creative approaches (Cremin, Glauert, Craft, Compton & Styliandou, 2015:414). So, for this research done in the South African context, the researcher identified four different synergies to be investigated between three different types of schools. Furthermore, for the purpose of the South African inquiry, it was decided to change the term “synergies” to “pedagogical phenomena”. This was done to accommodate the distinctive nature of the comparative research approach followed to investigate three different types of schools in the unique South African context.

Figure 3-4 shows how the structure of the Creative Little Scientists questionnaire (Creative Little Scientists, 2012a:153) assisted in utilising the raw data that were used to illuminate the pedagogical phenomena that formed the foundation of the empirical inquiry. This structure also reflects the relationship between the raw data, the pedagogical phenomena and the research questions.

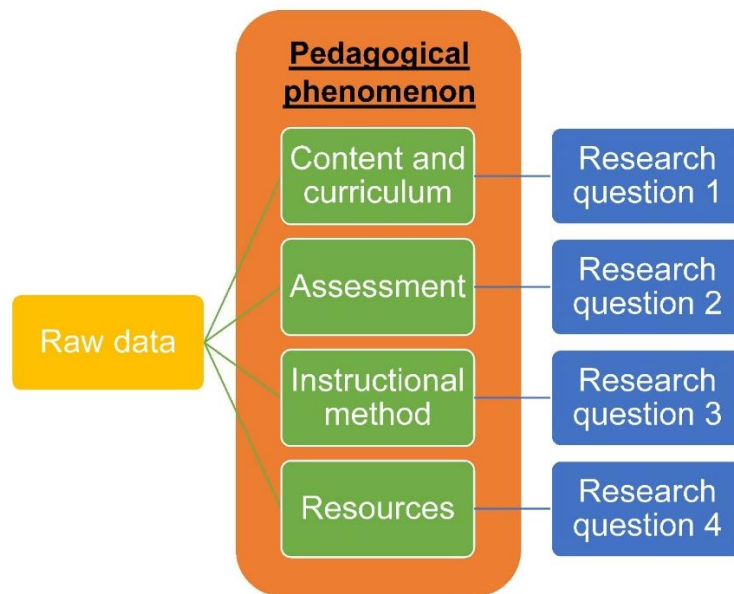


Figure 3-4: Conceptual framework

The Creative Little Scientists questionnaire (Creative Little Scientists, 2012a:153-172) was adapted for the context of South Africa (see Addenda A and B). For the purpose of this inquiry, the questionnaire used is called the “**adapted** Creative Little Scientists questionnaire”. The original Creative Little Scientists questionnaire consists of seven sections, namely: “1) background information – about your school, 2) background information – about you, 3) your knowledge, skills and confidence in teaching Science and Mathematics, 4) your views about and approaches in teaching Science, 5) your views about and approaches in assessing Science learning, 6) school Science and Mathematics resources and your use of them and lastly 7) thanking you and further communication” (Creative Little Scientists, 2012a:153).

The structure of the adapted Creative Little Scientists questionnaire corresponds to the first six sections of the original Creative Little Scientists questionnaire (see Addendum A). Section 7 of the Creative Little Scientists questionnaire did not form part of the adapted South African questionnaire. The researcher retained the above-mentioned six sections for this inquiry in order to replicate the research done on the European continent, but in the South African context. The researcher utilised the first six sections of the original Creative Little Scientists questionnaire but customised them to a five-section questionnaire because of the specific South African context. The adapted questionnaire consisted of sections on the i) content and curriculum, ii) assessment, iii) instructional method, iv) resources and v) demographic information. As seen in Figure 3-4, Sections 1 to 4 of the adapted questionnaire relate to the four pedagogical phenomena of the conceptual framework speaking to the research questions.

According to Handal and Herrington (2003:60), content and curriculum are prescribed by the curriculum of a country and can be interpreted in three different ways. Firstly, the intended curriculum refers to the policy documents and material that are prescribed by the policymakers (what teachers are prescribed to teach). Secondly, the implemented curriculum refers to how the curriculum is interpreted by teachers and what is done by teachers and learners in the classroom. Lastly, the attained curriculum refers to the learning experience perceived by learners and the assessment of what learners know.

The questions in the adapted Creative Little Scientists questionnaire (see Addendum B) provided data on both the intended curriculum and the implemented curriculum. In other words, these questions illuminated, on the one hand, the teachers' understanding of the current South African policy documents related to STEM education in Grade R to 3 (Foundation Phase) and, on the other, based on their interpretation of the policy documents, what they actually did in their classrooms on a daily basis. The four pedagogical phenomena of the conceptual framework – content and curriculum, assessment, instructional method and resources – are linked to specific questions from the adapted Creative Little Scientists questionnaire.

3.5.1 Content and curriculum

The following questions dealt with the teachers' comprehension of STEM content and curriculum in Grades R to 3 in South Africa:

- Question 10 – the time allocated per week for teaching Mathematics and Science
- Question 11 – themes that the teacher teaches throughout the year
- Question 12 – the teacher's views on the importance of Science subjects in compulsory education
- Question 13 – how often the teacher fosters the development of Science learning outcomes
- Question 14 – how often the teacher fosters the development of Mathematics learning outcomes

3.5.2 Assessment

The following questions dealt with the teachers' comprehension of STEM assessment in Grades R to 3 in South Africa:

- Question 22 – the teacher's views on the importance of assessment of Science in the age group that he or she teaches

- Question 23 – the teacher's views on the importance of assessment of Mathematics in the age group that he or she teaches
- Question 24 – how often the teacher assesses learners in Science using artefacts, relevant gestures, physical activity or verbal feedback
- Question 25 – how often the teacher assesses learners in Mathematics using artefacts, relevant gestures, physical activity or verbal feedback
- Question 26 – how often the teacher rewards or praises learners in the Science class
- Question 27 – how often the teacher rewards or praises learners in the Mathematics class
- Question 28 – how often the teacher assesses learners to determine their progression, development and improvement in Science
- Question 29 – how often the teacher assesses learners to determine their progression, development and improvement in Mathematics

3.5.3 Instructional method

The following questions dealt with the teachers' comprehension of STEM instructional methods in Grades R to 3 in South Africa:

- Question 15 – how often the teacher uses specific learning and teaching contexts and approaches when teaching Science
- Question 16 – how often the teacher uses specific learning and teaching contexts and approaches when teaching Mathematics
- Question 17 – how often the teacher encourages activities such as observation, design and construction in Science
- Question 18 – how often the teacher encourages activities such as observation, design and construction in Mathematics
- Question 19 – what approach – open, guided or structured – the teacher follows in the Science classroom
- Question 20 – what approach – open, guided or structured – the teacher follows in the Mathematics classroom
- Question 21 – the teacher's view on the role of the teacher in fostering inquiry skills

3.5.4 Resources

The following questions dealt with the teachers' comprehension of STEM resources in Grades R to 3 in South Africa:

- Question 30 – the availability of resources for Science at the school

- Question 31 – the availability of resources for Mathematics at the school
- Question 32 – how often the available resources are used in the teaching of Science
- Question 33 – how often the available resources are used in the teaching of Mathematics
- Question 34 – what resources are consulted by the teacher in preparation for Science lessons
- Question 35 – what resources are consulted by the teacher in preparation for Mathematics lessons

The above four pedagogical phenomena supported the framework of the inquiry with regard to the research aims and objectives, the context of the inquiry, the population and the sampling method.

3.6 Level 5 – Research design

The term “research design” refers to how one’s research is designed. This describes the way that the research project is designed in terms of the way in which the data are created, collected, constructed, coded, analysed and interpreted (Perri 6 & Bellamy, 2012:20).

3.6.1 Research method

3.6.1.1 Mixed method

A mixed-method design refers to employing both qualitative and quantitative research methods and using tools from both methods to collect and analyse data. Employing a mixed-method approach allows the researcher to get a better understanding of the research problem than would have been provided by either qualitative or quantitative research methods alone (Creswell, 2008:62; Kansteiner & König, 2020:8). The value of mixed methods can be seen in the light of increasing the validity of one’s findings as using mixed methods calls for the collection of two or more types of data (Ary, Jacobs, Irvine & Walker, 2018:592; McKim, 2017). As such, the integration of components found within the different data collected contributes to a deeper understanding of the phenomenon. For this inquiry, the researcher made use of quantitatively-driven mixed-method research, as the qualitative data were used to broaden the understanding of the quantitative data (see Kansteiner & König, 2020:6). For example, the data collected by following the qualitative strategy (mapping of space/classrooms) contributed to obtaining a better understanding of the quantitative data (the questionnaire completed by the teachers).

3.6.1.2 Quantitative research method

Quantitative research tools include specific tests or experiments with the aim to provide numeric data. The purpose of quantitative research methods is to determine and examine the relationships between variables (Ary *et al.*, 2018:90). A variable refers to a specific characteristic or attribute of an individual that can be measured and may differ between individuals or organisations being observed (Creswell, 2014:52). This research method is structured and follows processes to examine the specific phenomenon. For this, a researcher specifies the variables, designs measurements for the variables and designs a scale for the analysis of the variables (Ary *et al.*, 2018:452). In quantitative research, a researcher can make use of either experimental or non-experimental strategies to gather data (Ary *et al.*, 2018:448). For this inquiry, a non-experimental strategy was used, where there was no manipulation of the variables of the phenomena (see Johnson & Christensen, 2008:43). The non-experimental strategy used in this inquiry was causal-comparative research. In causal-comparative research, the aim is to see a relationship between categorical independent variables (e.g. teachers from Farm schools, teachers from Township schools and teachers from Model C schools) and a quantitatively dependent variable (e.g. results of questionnaire questions) (Johnson & Christensen, 2008:43).

3.6.1.3 Qualitative research method

The purpose of qualitative research is to use different types of inquiry to understand social and cultural contexts by observing human participants in a natural setting (Ary *et al.*, 2018:24). Qualitative research seeks to understand the trends surrounding a specific phenomenon by viewing the participants and data as a holistic set rather than breaking them down into variables (Ary *et al.*, 2018:32). Such research tends to be unstructured and adaptable to the situation. Qualitative research relies on the participants' views and understanding of a particular subject in order to generate data that can be analysed by sorting the data into themes (Creswell, 2008:46). The qualitative research methodology seeks to understand the views of the participants by taking into consideration the context (social, historical, political and cultural influences) and the natural setting (classroom or school) of the participants (Ary *et al.*, 2018:447, 451). This research method makes use of humans as instruments and gathers data in the form of words, pictures and other visual information (Ary *et al.*, 2018:452). For this inquiry, the researcher made use of maps of the space (classroom), individual follow-up questions where needed and the collection of artefacts, including lesson plans and examples of learners' work, which generated data in the form of words and pictures from the participants.

3.6.2 Data collection tools

The five core instruments used to address the research questions were questionnaires completed by teachers, policy documents, a map of the space, individual interviews with teachers (if needed to clarify questions answered on the questionnaires) and artefacts.

3.6.2.1 Questionnaires completed by the teachers

The questions given below (see Addendum B) aimed to contribute to answering the research questions of this inquiry. The four research questions are provided, each with the relevant questions in the questionnaire pertaining to the research question of the current inquiry.

Research question 1: “How are the content and curriculum in Mathematics and Science of Grades R to 3 conceptualised by teachers from different types of schools (and in policy) in South Africa?”

The following questions from the adapted Creative Little Scientists questionnaire dealt with content and curriculum as a pedagogical phenomenon: Questions 10 (time allocated per week for teaching Mathematics and Science), 11 (themes that the teachers teach throughout the year), 12 (the teachers’ views on the importance of Science subjects in compulsory education), 13 (how often the teachers foster the development of Science learning outcomes) and 14 (how often the teachers foster the development of Mathematics learning outcomes).

Research question 2: “How does the assessment of Mathematics and Science affect teaching and learning activities in Grades R to 3 in different types of schools (and in policy) in South Africa?”

The following questions from the adapted Creative Little Scientists questionnaire dealt with assessment as a pedagogical phenomenon: Questions 22 (the teachers’ views on the importance of assessment of Science in the age group that they teach), 23 (the teachers’ views on the importance of assessment of Mathematics in the age group that they teach), 24 (how often the teacher assesses the learners in Science using artefacts, relevant gestures or physical activity or verbal feedback), 25 (how often does the teacher assess the learners in Mathematics using artefacts, relevant gestures, physical activity or verbal feedback), 26 (how often the teacher rewards or praises the learners in the Science class), 27 (how often the teacher rewards or praises the learners in the Mathematics class), 28 (how often the teacher assesses the learners to determine their progression, development and improvement in Science) and 29 (how often the teacher assesses the learners to determine their progression, development and improvement in Mathematics).

Research question 3: “What methods (inquiry-based, creativity and play) are used in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?” The following questions from the adapted Creative Little Scientists

questionnaire dealt with instructional methods as a pedagogical phenomenon: Questions 15 (how often the teacher uses specific learning and teaching contexts and approaches when teaching Science), 16 (how often the teacher uses specific learning and teaching contexts and approaches when teaching Mathematics), 17 (how often the teacher encourages activities such as observation, design and construction in Science), 18 (how often the teacher encourages activities such as observation, design and construction in Mathematics), 19 (what approach – open, guided or structured – the teacher follows in the Science classroom), 20 (what approach – open, guided or structured – the teacher follows in the Mathematics classroom) and 21 (the teacher's view on the role of the teacher in fostering inquiry skills).

Research question 4: "What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?" The following questions from the adapted Creative Little Scientists questionnaire dealt with resources as a pedagogical phenomenon: Questions 30 (the availability of resources for Science at the school), 31 (the availability of resources for Mathematics at the school), 32 (how often the available resources are used in the teaching of Science), 33 (how often the available resources are used in the teaching of Mathematics), 34 (what resources are consulted by the teacher in preparation for Science lessons) and 35 (what resources are consulted by the teacher in preparation for Mathematics lessons).

3.6.2.2 Policy documents

Data gathered from policy documents were used to partially (in conjunction with the questionnaires, maps and artefacts) answer Research question 1 (How are the content and curriculum in Mathematics and Science of Grades R to 3 conceptualised by teachers from different types of schools [and in policy] in South Africa?), Research question 2 (How does the assessment of Mathematics and Science affect teaching and learning activities in Grades R to 3 in different types of schools [and in policy] in South Africa?), Research question 3 (What methods – inquiry-based, creativity and play – are used in the teaching of Mathematics and Science Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?) and Research question 4 (What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?). The available educational policy documents from South Africa were collected and analysed to answer the research question and support the collected data. Policy documents used in this analysis were the key documents provided to teachers by the Department of Basic Education in South Africa. These documents were the Curriculum and Assessment Policy Statement (CAPS), Annual teaching plan (ATP) and the School Based Assessment (SBA) policy documents for both Life Skills and Mathematics Grades R to 3.

3.6.2.3 A map of the space (i.e., classroom)

The data from the maps of the space (i.e. the classroom) were used to support the findings from the questionnaire with regard to Research question 3 (What methods – inquiry-based, creativity and play – are used in the teaching of Mathematics and Science Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?) and Research question 4 (What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?). The reason for collecting data reflecting the mapping of the spaces was to assist the researcher by giving a context in order to interpret the questions on the utilisation of resources.

3.6.2.4 Individual interviews with teachers (if needed to clarify questions answered on the questionnaires)

Individual follow-up interviews were used to clarify answers given in the questionnaires. This was only done with individual teachers where further clarification of a question or observation was needed. The data from the interviews thus support the findings of the questionnaires in answering three research questions, namely Research question 1 (How are the content and curriculum in Mathematics and Science of Grades R to 3 conceptualised by teachers from different types of schools [and in policy] in South Africa?), Research question 3 (What methods – inquiry-based, creativity and play – are used in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?) and Research question 4 (What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?).

3.6.2.5 Artefacts

Data gathered from artefacts were used to support the findings from the questionnaire and, therefore, support the answering of three research questions, namely Research question 1 (How are the content and curriculum in Mathematics and Science of Grades R to 3 conceptualised by teachers from different types of schools [and in policy] in South Africa?), Research question 3 (What methods – inquiry-based, creativity and play – are used in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?) and Research question 4 (What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools [and in policy] in South Africa?).

The artefacts included teachers' lesson plans, examples of learners' classwork and policy documents used for preparing for teaching and learning activities. The collection of artefacts

enabled the researcher to construct a better understanding of the classroom context and how the teachers engaged in different teaching and learning activities. Furthermore, by studying the artefacts, the researcher gained insight into the interpretation of policy documents after the researcher had left the research site.

3.6.3 Context of the inquiry

Comparative education seeks to study a specific phenomenon in education, either on a national or an international level, while not excluding external factors and issues such as ethnicity, race, age, religion or gender (Creative Little Scientists, 2012e:8). A criterion for a comparative education study is that the study compares at least two different types of schools (Creative Little Scientists, 2012e:9). The value of comparative education lies in the analysis of the structure and functioning of an education system, taking into consideration external determinants (external factors that influence education), such as economics, science and technology, religion, language, geography, demography and politics, in order to improve and renew another education system. For the purpose of this inquiry, a comparison between three types of schools in South Africa, namely Model C schools, Township schools and Farm schools, was made.

The reason for the choice of these types of schools is that they represent the larger population of South Africa as public schools (as seen in Table 3-1 below) and can, therefore, provide a more complete picture of education in South Africa. As there are various external and internal determinants at play in these different types of schools, one can presume that they have different challenges in the provision of education to their complex population and the provision of STEM education in Grades R to 3.

Table 3-1: Public versus independent schools, learners and teachers in South Africa (Department of Basic Education, 2022b:1)

Province	Public			Independent		
	Learners	Teachers	Schools	Learners	Teachers	Schools
Eastern Cape	1 772 877	58 824	5 109	75 176	3 874	232
Free State	706 269	22 686	990	20 444	1 181	81
Gauteng	2 227 733	72 132	2 067	337 079	19 796	874
KwaZulu-Natal	2 831 417	92 232	5 801	62 541	4 427	221
Limpopo	1 723 583	50 021	3 675	75 547	3 561	180
Mpumalanga	1 101 224	34 837	1 654	33 665	2 126	131
Northern Cape	298 253	9 984	545	6 313	502	40
North West	848 086	26 796	1 450	24 515	1 458	89
Western Cape	1 196 715	37 508	1 449	67 812	5 154	306
National	12 706 157	405 050	22 740	703 092	42 073	2 154

The Creative Little Scientists (2012e:26) consortium compared various countries and schools by making use of statistical tools to see to what extent they were different or similar regarding the issues of STEM education and how the comparison could translate into designing a protocol for best practices that could be applied to different contexts while making sure that diversity was acknowledged while, simultaneously, there was a striving for excellence. In the current inquiry, the researcher aimed to gather data on the similarities and differences regarding STEM education in the different types of schools in South Africa in order to design a protocol for best practices in South Africa.

3.6.3.1 Population

In this inquiry, the researcher sought to document and analyse the current perception of teachers with regard to STEM-related subjects in Foundation Phase (Grade R to 3) education. Therefore, the target population of this inquiry was in-service teachers of Grade R to 3 learners in South Africa. Due to the complex nature of the general population in South Africa, the researcher aimed to include specific schools with multi-cultural learners of different ethnicities, from different socio-economic status groups and representing different contextual issues, as such a population would represent an authentic South African context.

For the purpose of this inquiry, the focus was on teachers in service at Model C schools, Township schools and Farm schools. Model C schools are government schools that are administrated and mostly funded by school governing bodies consisting of parents and alumni (Global Media, 2017). Model C schools often raise supplementary funds in order to employ additional teachers (Timæus, Simelane & Letsoalo, 2013:271). Township schools are schools situated in former settlements of the apartheid regime (Hens *et al.*, 2010:908). Farm schools are schools situated on a piece of farm land/rural area and are often not within walking distance from an Urban or Township school (Department of Basic Education, 2010:105).

3.6.3.2 Sampling

3.6.3.2.1 Sampling technique

For its project, the Creative Little Scientists (2012f:28) consortium used purposive sampling with the following inclusion criteria for sites:

- Includes appropriate diversity (e.g. in respect of culture, circumstances and language)
- Covers appropriate age span of three to eight years
- Settings primarily focused on education, not care
- Represents a span of mainstream early years education provision
- Geographical accessibility for researchers

- Allows the Creative Little Scientists team to mine one or more of the important research foci

Due to the specific nature of the participants needed for this inquiry, the researcher made use of specialist group sampling. As the researcher aimed to determine the status of the teaching, learning and assessment of STEM subjects in Grades R to 3, the participants needed to be part of the specialist group as mentioned above (see Newby, 2014:255-6). These teachers who formed part of the specialist group were able to provide accurate data with regard to their perceptions and beliefs. The specialist teachers were selected based on the following criteria: an in-service teacher at a selected school within a selected site, teacher in the Foundation Phase (Grades R to 3). Furthermore, as the researcher aimed to provide an accurate comparison between different types of schools in South Africa, the selected schools that most accurately reflected the situation in the country and the context of the teachers.

3.6.3.2.2 Sampling size

As the researcher aimed to recreate the Creative Little Scientists method of sampling, the sample size as set in the Creative Little Scientists (2012f:37) guidelines for fieldwork was adapted for this inquiry. The Creative Little Scientists (2012f:37) consortium highlights the importance of selecting sites that vary in terms of location and the age of the children. The team aimed to collect data from each participating country that had depth and not breadth within the time constraints of the study (Creative Little Scientists, 2012f:27). Therefore, the Creative Little Scientists team indicates a set of criteria, as seen in Table 3-2, as a checklist for including a proposed site (school) (Creative Little Scientists, 2012f:46).

Table 3-2: Creative Little Scientists general selection criteria (Creative Little Scientists, 2012f:46)

General selection criteria	
Phase	Preschool School
Governance	State Private Voluntary
Age of children	3-8
Special school	N/A
High diversity	SEN [Special educational needs] Non-native speakers Socio-economic disadvantage
Location	Urban Suburban Rural

The above general selection criteria were adapted for the context of South Africa. The adapted general selection criteria for South Africa are presented in Table 3-3.

Table 3-3: General selection criteria for South Africa

General selection criteria	
Phase	Primary school (Grades R-7)
Governance	State
Age of children	5-10
High diversity	Native and non-native speakers Socio-economic disadvantage (Quintile 1-4)
Location	Urban Township Rural

The Creative Little Scientists team prescribes a minimum of four sites (actual schools), five where possible, per participating country. From each site, a minimum of six cases (identified as one teacher and his or her learners/classroom) were selected (Creative Little Scientists, 2012f:27). With the criteria from the Creative Little Scientists study in mind, the researcher selected sites from three different types of schools in South Africa. The use of three different types of schools allowed the researcher to understand the state of education in that region. As the responses to the questionnaires might vary for different age groups, the researcher selected a range of case samples throughout Grades R to 3 instead of focusing on a single age group within the Foundation Phase. Each case documented a questionnaire completed by the teachers, a map of the classroom and resources, interviews conducted with the teachers (if needed) and artefacts, including samples of lesson plans and learners' work. Table 3-4 indicates the chosen types of schools, the number of sites and the number of cases collected at each school. It is important to note that due to restrictions with regard to collecting data during the course of the Covid-19 pandemic, this set of data was collected from sites in the North West Province of South Africa.

Table 3-4: Sample sites in South Africa

Type of school	Site	Cases	Quintile category
Farm school	• School A	• 1 classroom (1 teacher Grades 1-3)	• Quintile 1 (no-fee school)
	• School B	• 3 classrooms	• Quintile 1 (no-fee school)
	• School C	• 5 classrooms	• Quintile 1 (no-fee school)
Township school	• School D	• 4 classrooms	• Quintile 2 (no-fee school)
	• School E	• 4 classrooms	• Quintile 3 (no-fee school)
	• School F	• 7 classrooms	• Quintile 3 (no-fee school)
	• School G	• 4 classrooms	• Quintile 1 (no-fee school)

Model C school	• School H	• 7 classrooms	• Quintile 4 (fee-paying school)

Although the Creative Little Scientists consortium calls for six cases per site, this inquiry was adapted to the availability of teachers at specific schools. In the case of School A (Farm school), one teacher taught Mathematics for Grades 1, 2 and 3. To accommodate such discrepancies, eight sites that fit the general criteria of Creative Little Scientists were identified. The Creative Little Scientists sample size calls for a total of four or five sites (schools) and six cases (teachers and their classrooms) per site, giving a maximum total of 30 cases per country. In this inquiry, the researcher aimed to make use of eight sites with between one and seven cases at each site, giving a total of 35 cases (teachers and their classrooms) in South Africa.

3.6.4 Validity and reliability

Validity refers to the truthfulness of the measuring instruments used in an inquiry and how accurate the findings reflect the true data (Mohajan, 2017:58; Noble & Smith 2015:1). Reliability describes the stability of the measuring instrument to control random errors within the analytical procedures (Mohajan, 2017:59; Noble & Smith, 2015:1). Consequently, both validity and reliability enhance the transparency of the gathered and reported data and ensure that the risk of researcher bias towards qualitative data is decreased (Mohajan, 2017:59).

The Creative Little Scientists consortium used specific measuring instruments in the collection of data. In this inquiry, the researcher made use of the same measuring instruments to collect the data. The measuring tools had already been designed and tested for validity and reliability by the Creative Little Scientists team. According to Creative Little Scientists (2012f:30), validity and reliability are achieved by the following features: Credibility is ensured by the dissemination and application of findings. The intent of the research tools is to gather data that can inform and guide future initial teacher training or initial teacher education and the provision of continuing professional development (Creative Little Scientists, 2012f:30). Rigour is ensured by building on previous background information, which ensures that the correct approach for the collection and analysis of data is used and that the findings are transferable to a range of different cultures (Creative Little Scientists, 2012f:30). In the Creative Little Scientists project, transferability was achieved by designing tools for data collection that could be used in a comparative study across nine countries in Europe (Creative Little Scientists, 2012f:31).

Although the Creative Little Scientists questionnaire had been standardised and utilised across nine European countries, the researcher took several further precautions in this inquiry to ensure the validity and reliability of the inquiry in terms of the South African context. Firstly, the researcher

adapted the original Creative Little Scientists questionnaire to suit South African conditions. Secondly, the adapted questionnaire was sent to a STEM specialist in South Africa for scrutiny.

3.6.5 Ethical considerations

The most important function of ethics in research is to protect the rights of all the participants (Maree & Van der Westhuizen, 2012:41; Marshall & Rossman, 2011:47; Mouton, 2011:239). Mouton (2011:239-245) notes that this should include the ethical aspects of confidentiality, the means of gathering data, the publication of data and the impact that a researcher has on the research environment.

In this inquiry, the researcher used an independent party for all aspects of the collection of the data. This insured that the identity of the participants was kept confidential. Furthermore, all the data that were gathered were in the form of paper-based documents, visual representations and psychical artefacts. The researcher used an independent party to inform the participants of the process of gathering data for this inquiry and to obtain their informed consent. The participants were ensured that all of the data would be utilised strictly for the purpose of this inquiry and that the researcher would adhere to the strict ethical framework set out by the North-West University. Because the researcher did not physically interact with any of the participants, there was limited, if any, impact on the research environment. The researcher completed a comprehensive ethics training course and, thereafter, submitted an ethics proposal to the faculty of education ethics committee of the North-West University for review. Before the research was executed, the researcher received official ethical clearance for the inquiry in the form of an ethics certificate with an ethics number (see Addendum D).

3.6.6 Data organisation and analysis

The above-mentioned five data collection instruments were analysed in order to get a comprehensive picture of the participants' context, experiences and perceptions. The nature of the data can be subdivided into two main categories, namely i) quantitative data (a four- or five-point Likert scale questionnaire) and ii) qualitative data (a map of the space, policy documents, open-ended follow-up interviews and classroom artefacts).

Creative Little Scientist team made use of descriptive statistics by converting the responses of teachers (of the questionnaire) into percentages (Stylianidou, Glauert, Rossis & Havu-Nuutinen, 2016:5). Thereafter comparative analysis of each questionnaire item showed the similarities and difference of teachers responses. This inquiry used the same method to structure and analyse the gathered data as prescribed by the Creative Little Scientist team. The quantitative data were

analysed by converting the responses of the teachers (in the questionnaire) into percentages. The results from the adapted questionnaire reflecting the findings related to the four pedagogical phenomena produced 248 graphs indicating the responses of the participants from the three different schools. Then the results from these 248 graphs were fused into 73 graphs retaining the key findings (see Addendum C).

Multiple sets of visual data have been analysed by using a strategy of identification and interpretation. Visual data refers to any kind of visual material that provides meaning and significance to the study (Knoblauch, Baer, Laurier, Petschke, & Schnettler, 2008). The qualitative data were analysed by utilising a framework reflecting the presence of the following four main phenomena, namely i) map of space, ii) policy documents, iii) open-ended follow-up interviews and iv) classroom artefacts. The mapping of spaces involved the identification of the spatial layout, the number and nature of physical resources, the number and nature of textbooks and storybooks, stationery, educational toys, floor carpets, outside play areas and computer centres. The analysis of the policy documents involved analysing all relevant existing documents pertaining to STEM education in Grade R to 3 (Foundation Phase) in South Africa (see the bibliography). The open-ended follow-up interviews were analysed through extensive scrutiny of field notes made during the interviews. The data obtained from the artefacts (teacher lesson plans and learners' work) were aligned with the feedback provided in the questionnaires.

3.7 Summary

In this chapter, a Matryoshka doll was used as a model representing the interrelationship between the different components of the research design. In other words, the chapter dealt with the conceptual framework underpinning the entire design. Furthermore, the aims and objectives that guided this inquiry were defined, and the nature and size of the population that was used in the inquiry were delineated. In addition, the data collection tools, the data-gathering method and the method of analysis were described. Lastly, the validity and reliability of the inquiry, along with the ethical considerations of the inquiry, were discussed.

CHAPTER 4 DATA ANALYSIS AND RESULTS

4.1 Keywords and abbreviations

4.1.1 Annual Teaching Plan

The Annual Teaching Plan (ATP) is a national policy document that provides teachers in each grade with a detailed breakdown of the weeks of each term. Under each week, the context of the content to be taught during the course of that week is described. The ATP is amended each year, and teachers are provided with a new document each year. In the ATP for Mathematics Grades R to 3, the core concepts, skills and values, strategies of teaching, required pre-knowledge, a list of resources and the informal and formal assessments needed for the teaching and learning activities in that week are given (Department of Basic Education, 2021a:1-3).

The ATP for Life Skills Grades R to 3 is broken down into the four learning areas of Life Skills, namely Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2021c:11-22). Each learning area is then further divided. Under the learning area of Personal and Social Well-being, three categories are provided: skills and values; core concepts and knowledge; and CAPS content. In order to ensure optimal use of the Department of Basic Education workbooks, resources, informal assessment and formal assessment are discussed for each topic. Furthermore, under the Beginning Knowledge learning area, a breakdown of skills and values, knowledge (conceptual key points), CAPS content, reading for meaning, resources and informal and school-based assessment (SBA) is provided (Department of Basic Education, 2021c:11-22). Under the Creative Arts learning area, tasks are provided under the following categories: create in 2D (two-dimensional work); create in 3D (three-dimensional work); visual literacy; creative games and skills; improvise and interpret; and informal and school-based assessment (Department of Basic Education, 2021c:11-22). Lastly, under Physical Education, the activities are categorised under skills, locomotor, perceptual-motor, laterality, sports and games, informal assessment and school-based assessment (Department of Basic Education, 2021c:11-22).

4.1.2 Artefacts

Artefacts are data that are observed and recorded that provide context and support other data collected. The broad term “artefact” is used for a range of different materials, including teachers’ lesson plans and examples of learners’ classwork, homework or worksheets (Creative Little Scientists, 2012f:63).

4.1.3 Curriculum and Assessment Policy Statement

The *Curriculum and Assessment Policy Statement (CAPS)* is a document that provides the policy statement for teaching and learning in South African schools. This document provides teachers with a policy statement for the approved school subjects, the programme and promotion requirements of each grade and the assessment protocol for each grade (Department of Basic Education, 2011a:3). Furthermore, the CAPS document provides the time allocation for each subject in each phase, the background of the subject area, the types of activities and skills, the resources needed for the teaching and learning activities of the subject and an outline of the course material (topics) (Department of Basic Education, 2011a:3-65).

4.1.4 Curriculum and Assessment Policy Statement (CAPS) topics

The subject content of the Curriculum and Assessment Policy is organised into different topics. In the subject of Life Skills, the content of the curriculum in the learning areas of Beginning Knowledge and Personal and Social Well-being is organised into topics. The topics provide a platform for integrating the content from the four learning areas of Life Skills where possible (Department of Basic Education, 2011a:14). Although the ATP refers to CAPS topics in Mathematics, Mathematics in Grade R to 3 (Foundation Phase) covers five content areas. These content areas are not integrated, and each of the content areas has a number of specific skills that learners need to develop (Department of Basic Education, 2011b:9-10).

4.1.5 Department of Education workbook

The Department of Basic Education provides an individual workbook for each subject to each learner in each grade. These workbooks are designed and distributed by the Department of Basic Education and are aimed at improving learners' overall performance (Department of Basic Education, 2021d). The workbooks consist of 128 worksheets, with four worksheets to be completed per week. Each learner in Grades 1-9 receives two of these workbooks per year, while Grade R learners receive four workbooks per year (Department of Basic Education, 2021d). The ATP provides guidelines for each page of the workbook to be completed under each topic.

4.1.6 Farm schools

A Farm school is a public school that is situated on private property (a farm), often in rural areas (Department of Basic Education, 2010:105). Rural areas are defined as an area with lower population densities, low levels of economic activities and low levels of infrastructure (Department

of Basic Education, 2010:100). Due to the nature of the education and social landscape of South Africa, most of the teachers and learners in these schools are black.

4.1.7 Model C schools

Model C schools are public schools that are administrated and mostly funded by governing bodies consisting of parents and alumni (Global Media, 2017). These schools still receive a subsidy from the provincial education department in terms of Section 21 of the *South African Schools Act* 84 of 1996.

4.1.8 School-based Assessment (SBA) Exemplar Booklet

The *SBA Exemplar Booklet* is a document that provides teachers with a guideline to develop standardised tasks and assessment tools. The document includes formal assessment guidelines with rubrics and checklists (Department of Basic Education, 2018a:1).

4.1.9 Township schools

Township schools are situated in former settlements of the apartheid regime (Hens *et al.*, 2010:908). These schools are dependent on and fully funded by the government; learners are exempted from paying school fees, and provision is made for a feeding scheme for learners (Rollnick & Mavhunga, 2014:357). Again, due to the nature of the education and social landscape of South Africa, most of the teachers and learners in these schools are black.

4.2 Introduction

In this chapter, the researcher aims to provide insight into the current perceptions of in-service teachers in different types of schools in South Africa with regard to Science and Mathematics education. The gathered data describe the participating teachers' perceptions with regard to Science and Mathematics education in South Africa within the areas of content and curriculum, the assessment of learners, methods for teaching and learning and the availability and use of resources in planning and executing teaching and learning activities.

A standardised questionnaire (see Addendum A), compiled by Creative Little Scientists (2012a: 153-172) adapted for the context of South Africa (see Addendum B), was used for this inquiry. The data gathered from the questionnaire were supported by maps of the space (classroom), individual follow-up interviews, artefacts such as teachers' lesson plans and examples of learners'

classwork and education policy documents of South Africa. The data were collected from eight sites (schools), divided between Farm schools, Township schools and a Model C school. A total of 35 participants from the eight sites participated in the inquiry. Table 4-1 below gives a complete breakdown of the types of schools, sites, cases per site and the quintile category of each site (also see Table 3-4 in section 3.6.3.2.2).

Table 4-1: Sample sites

Type of school	Site	Cases	Quintile category
Farm school	- School A - School B - School C	1 class (1 teacher Grade 1-3) 3 classes 5 classes	- Quintile 1 (no-fee school) - Quintile 1 (no-fee school) - Quintile 1 (no-fee school)
Township school	- School D - School E - School F - School G	4 classes 4 classes 7 classes 4 classes	- Quintile 2 (no-fee school) - Quintile 3 (no-fee school) - Quintile 3 (no-fee school) - Quintile 1 (no-fee school)
Model C school	School H	7 classes	Quintile 4 (fee-paying school)

The participating sites fall within Quintiles 1 to 4. The quintile refers to one of five poverty-based categories that are allocated to public schools. Quintile 1 schools are the poorest category, while Quintile 5 is the least poor category. Quintile categories are assigned according to national criteria. Quintile 1 and 2 schools are no-fee schools that may not enforce compulsory school fees (Department of Basic Education, 2010:77, 95).

Figure 4-1 (also see Figure 3-4 in section 3.5) below indicates the conceptual framework used for this inquiry. The results from the Creative Little Scientists questionnaire, maps of the space (classroom), artefacts and education policy documents of South Africa are grouped under the appropriate pedagogical phenomenon. The results from the adapted Creative Little Scientists questionnaire are grouped as follows: demographic information about the participants: questions 1 to 9; the pedagogical phenomenon of content and curriculum: questions 10 to 14; the pedagogical phenomenon of assessment: questions 22 to 29; the pedagogical phenomenon of method: questions 15 to 21; and the pedagogical phenomenon of resources: questions 30 to 35.

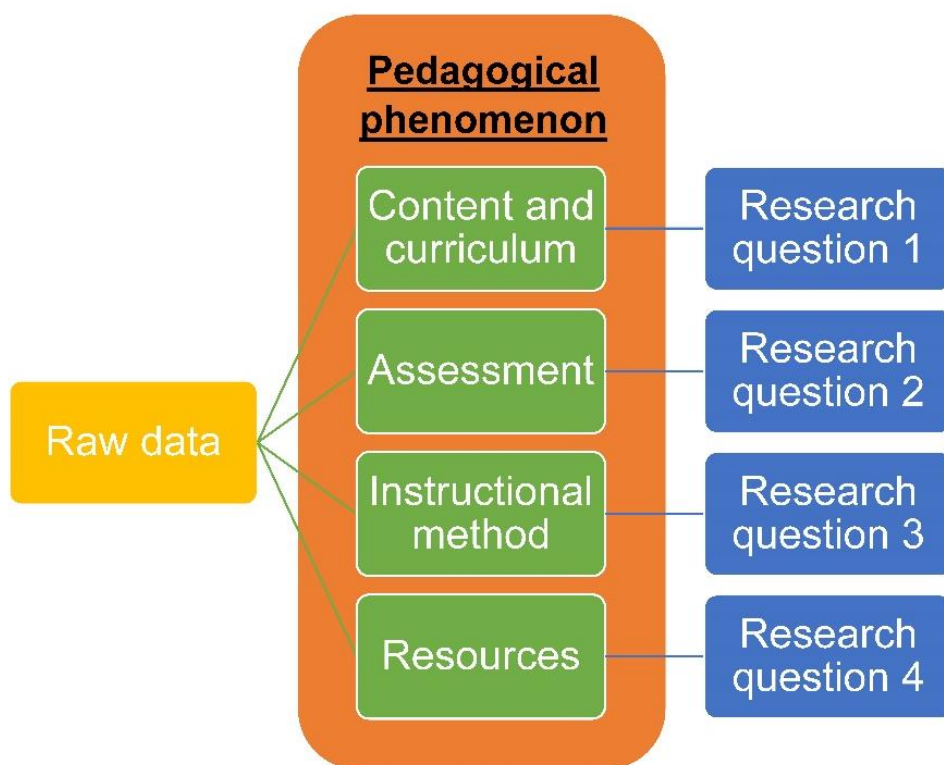


Figure 4-1: Conceptual framework

The structure of the discussions is guided by the results from the adapted Creative Little Scientists questionnaire. Under each question, the structure of the results is an interpretation of the findings and represented in the graphs, followed by a sequential discussion of the applicable South African policy, namely the CAPS, ATP and SBA policy documents of Life Skills and Mathematics in Grade R to 3 (Foundation Phase) or other applicable literature. Thereafter, a conclusion of the findings follows.

It is important to note that several of the participants returned the questionnaire indicating that they did not teach a Science subject in Grades R to 3 (Foundation Phase) and thus had not completed any questions related to teaching Science. The percentage of participants who did not answer a specific question is indicated in both the graph and the interpretation of the findings.

4.3 Demographic information of the participants

The Figure 4-2 below indicates the demographical information of the teachers as participants of this inquiry. The 35 participants are current in-service teachers from three different types of schools in South Africa, namely Farm schools, Township schools and Model C schools. The participating teachers are all currently teaching in Grades R to 3 (Foundation Phase). They

represent different age groups, levels of qualification and years of experience in teaching. However, all of the participants are female.

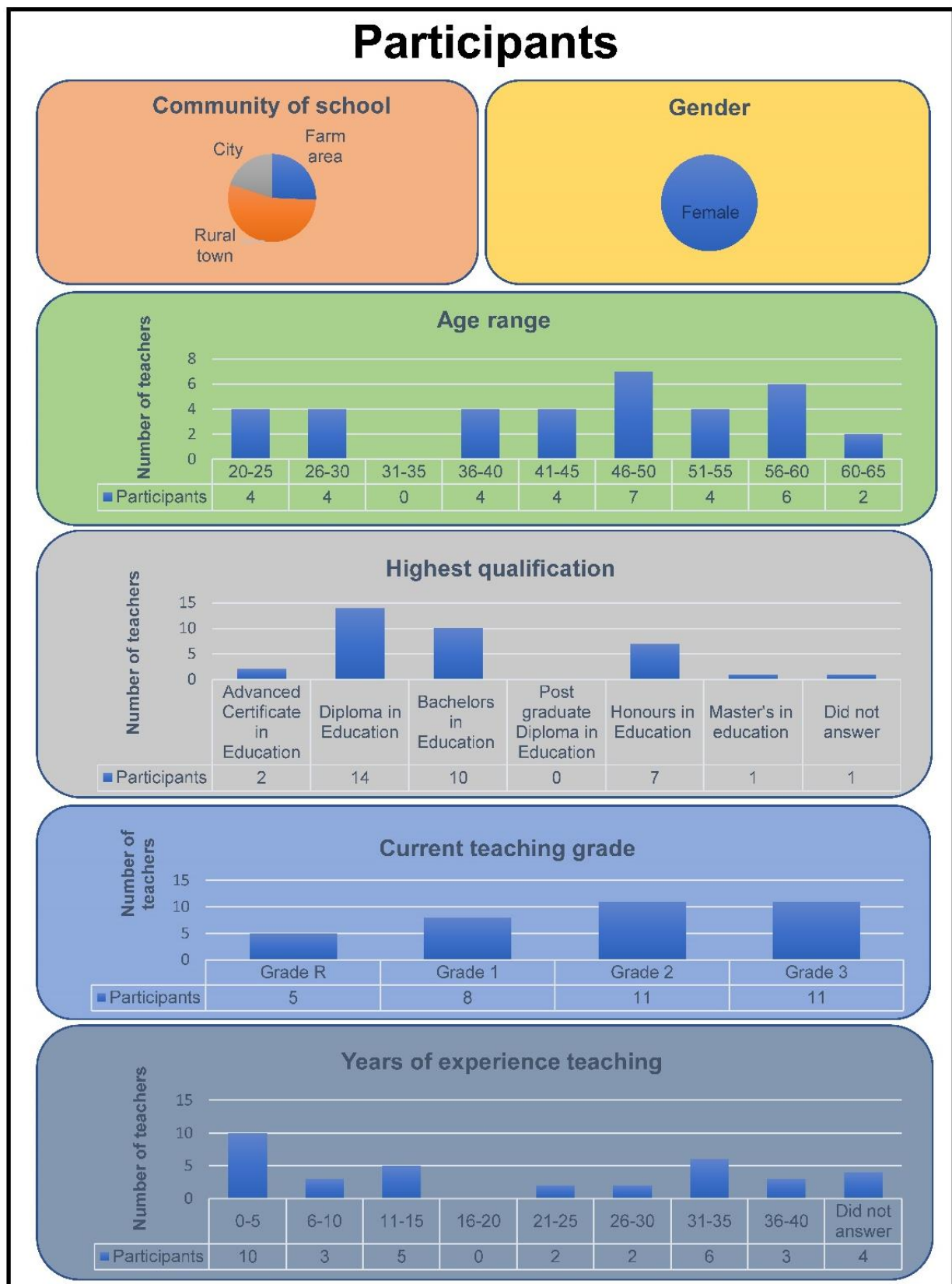


Figure 4-2: Demographic information of the participants

Table 4-2 and Figure 4-3 below indicate the demographic information of the schools and the average classroom size of the participants partaking in this inquiry.

Table 4-2: Learners per site

Type of school	Site	Learners per school
Farm school	School A	201-500 learners
Farm school	School B	201-500 learners
Farm school	School C	501-750 learners
Township school	School D	201-500 learners
Township school	School E	751-1000 learners
Township school	School F	1501-2000 learners
Township school	School G	751-1000 learners
Model C school	School H	751-1000 learners



Figure 4-3: Class sizes of the participants

In South Africa, according to regulations, learners apply to a school closest to their place of residence. Farm schools accommodate learners from the surrounding farms/rural area. The classroom sizes of these Farm schools vary, with 36 to 40 learners per class as the most common size. Township schools accommodate learners from former settlements and surrounding areas. Most of the participants have classrooms of between 31 and 40+ learners. Model C schools accommodate learners from the closest suburbs. The classroom size of the participating Model

C school is 26 to 30 learners. From the above data, it can be seen that the teacher-to-learner ratio is very high in Township schools and lower in Model C schools.

4.4 Pedagogical phenomenon: content and curriculum

The following questions from the adapted Creative Little Scientists questionnaire provided data supporting the pedagogical phenomenon of content and curriculum in South Africa: Questions 10 (the time allocated per week for teaching Mathematics and Science), 11 (themes the teacher teaches throughout the year), 12 (the teacher's view on the importance of Science subjects in compulsory education), 13 (how often the teacher fosters the development of Science learning outcomes) and 14 (how often the teachers foster the development of Mathematics learning outcomes).

4.4.1 Question 10 of the adapted Creative Little Scientists questionnaire

Question 10 was “**Approximately how much time do you have planned for teaching Science and Mathematics per week?**”. Table 4-3 shows the structure of possible choices per subject.

Table 4-3: Time spent on planning

	Science	Mathematics
a. Less than an hour		
b. 1-2 hours		
c. 3-4 hours		
d. More than 4 hours		
e. N/A (please explain)		

According to the CAPS policy document, three subjects, namely Home Language, Mathematics and Life Skills, are prescribed for learners in Grade R. For learners in Grades 1, 2 and 3, four subjects are prescribed, namely Home Language, First Additional Language, Mathematics and Life Skills. The CAPS policy document indicates that Grade R, 1 and 2 learners are allocated 23 hours of instructional time per week, while Grade 3 learners have a total of 25 instructional hours per week (Department of Basic Education, 2011a:6). In Table 4-4, the prescribed hours per week per subject for each Grade are indicated.

Table 4-4: Hours prescribed per subject in the CAPS policy document (Department of Basic Education, 2011a:6)

Prescribed instructional hours per week per Grade				
Subject	Grade R (prescribed hours per week)	Grade 1 (prescribed hours per week)	Grade 2 (prescribed hours per week)	Grade 3 (prescribed hours per week)
Home Language	10	7/8	7/8	7/8
First Additional Language	-	2/3	2/3	3/4
Mathematics	7	7	7	7
Life Skills	6	6	6	7
Total	23	23	23	25

Figures 4-4 indicates the data gathered from the participants on the number of hours that they allocate to the teaching of Science during the course of a week.

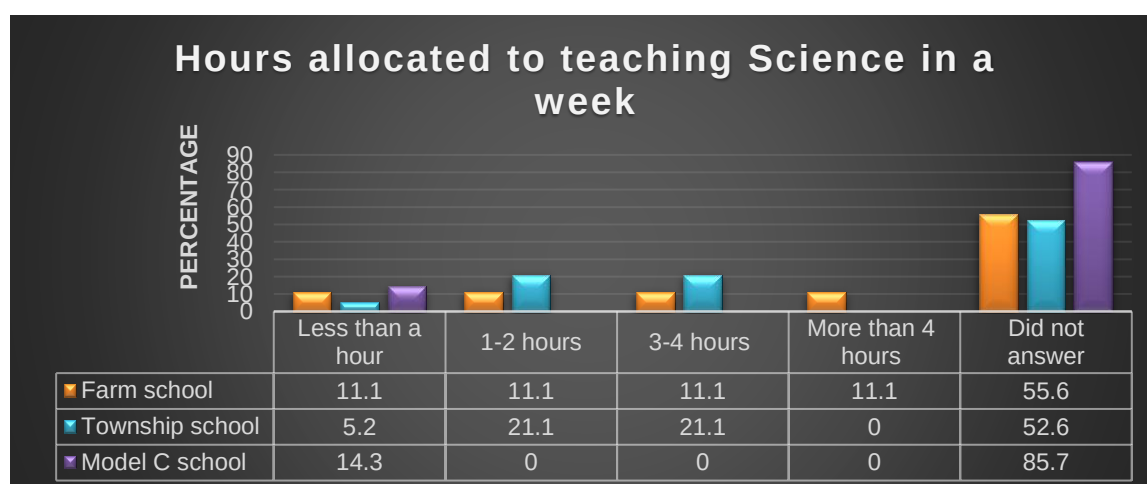


Figure 4-4: Hours dedicated to teaching Science

Of the participating teachers, 64.6% opted not to answer the question on the dedication of hours for Science teaching during each week. The remaining participants from the Farm and Township schools indicated that they allocated one to four hours per week to teaching Science. The participants from the Model C school indicated that they spent less than an hour teaching Science.

The Sciences are integrated within the Life Skills subject, which is subdivided into four learning areas, namely Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2011a:6). The subject of Life Skills is allocated a total of six hours per week for Grade R, 1 and 2 learners and seven hours per week for Grade 3 learners, as seen in the table below (Department of Basic Education, 2011a:6).

Table 4-5: Hours prescribed per Life Skill learning area in CAPS (Department of Basic Education, 2011a:6)

Life Skills hour per week breakdown				
Subject	Grade R (prescribed hours per week)	Grade 1 (prescribed hours per week)	Grade 2 (prescribed hours per week)	Grade 3 (prescribed hours per week)
Beginning Knowledge	1	1	1	2
Creative Arts	2	2	2	2
Physical Education	2	2	2	2
Personal and Social Well-being	1	1	1	1
Total	6	6	6	7

Even with the time allocated to each of the learning areas per week, the ATP policy document prescribes that teachers incorporate CAPS topics into all four learning areas of Life Skills where possible (Department of Basic Education, 2021c:11-22). The policy document thus prescribes that activities are completed under a CAPS topic that includes skills, concepts and assessment in Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2021c:11-22). Because of the integrated nature of Life Skills, six hours of teaching are prescribed per week for learners in Grades R, 1 and 2 and seven hours per week for Grade 3 learners (Department of Basic Education, 2011a:6). However, the participants indicated that they spent less than the prescribed time on teaching Life Skills (integrated subject under which Science falls).

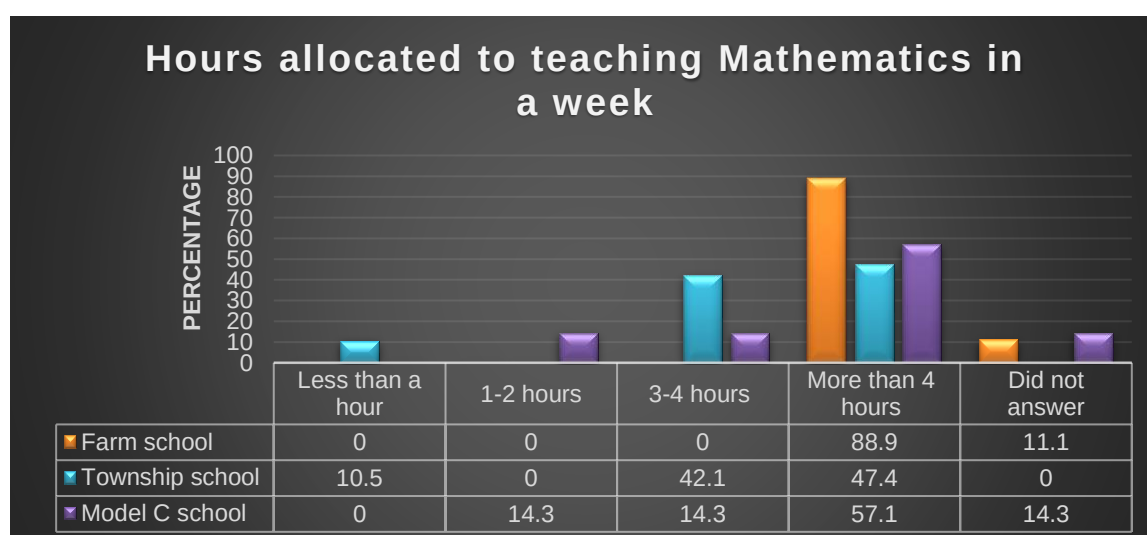


Figure 4-5: Hours dedicated to teaching Mathematics

A total of 8.5% of the participating teachers opted not to answer the question on the number of hours dedicated to Mathematics teaching during each week. Most of the teachers spend more than four hours per week on teaching Mathematics (see Figure 4-5).

According to the CAPS policy document, learners in Grades R, 1, 2 and 3 are prescribed seven hours per week (see Table 4-4) of instruction in the subject of Mathematics (Department of Basic Education, 2011a:6). The number of hours that the participants allocate to teaching Mathematics per week, as provided in Figure 4-5, falls within the prescribed number of hours indicated in the CAPS document to be spent on the teaching and learning activities for Mathematics (Department of Basic Education, 2011a:6).

4.4.2 Question 11 of the adapted Creative Little Scientists questionnaire

Question 11 was “List up to five **SCIENCE** and **MATHEMATICS** topics you have addressed in your teaching this school year”. See Table 4-6 below that was provided to the participants.

Table 4-6: Topics addressed in Science and Mathematics

	Science	Mathematics
a.		
b.		
c.		
d.		
e.		

As mentioned above (in Question 10, Section 4.4.1), the subject of Life Skills (integrated subject containing Science content) is divided into four learning areas, namely Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2011a:6). Both the CAPS and the ATP policy documents for Life Skills prescribe and encourage teachers to incorporate a given CAPS topic into all four of the learning areas (Department of Basic Education, 2011a:8; 2021c:11-22). An example of such integration is the CAPS topic called “insects” (see Question 34, Section 4.7.5, Table 4-43). Under Beginning Knowledge, learners complete activities about classifying types of insects. The topic of insects has to be continued in Creative Arts, where learners paint or draw insects based on what they have learnt about insects. The topic is extended further to Physical Education, where learners crawl like insects. Lastly, under Personal and Social Well-being, there is no connected activity, as there is no natural link between the knowledge of insects and the content of this learning area (Department of Basic Education, 2021c:11-22).

Although the subject of Life Skills is prescribed by policy documents to take place as an integrated subject, the topics that the participants provided can be categorised under Beginning Knowledge. Beginning Knowledge aims to provide learners with key concepts and skills related to Social Sciences, Natural Sciences and Technology. Beginning Knowledge is further divided into the sub-categories of Social Science concepts, Natural Science concepts, Scientific Process skills and Technological Process skills (Department of Basic Education, 2011a:8). Figure 4-6 below indicates where the topics addressed by the participants are located within the Life Skills subject.

The subject of Mathematics is subdivided into five learning areas, namely Number, Operations and Relationships; Patterns, Functions and Algebra; Space and Shape (Geometry); Measurement; and lastly, Data handling (Statistics) (Department of Basic Education, 2011b:10). Figure 4-7 below indicates the topics addressed by the participants under the five learning areas.

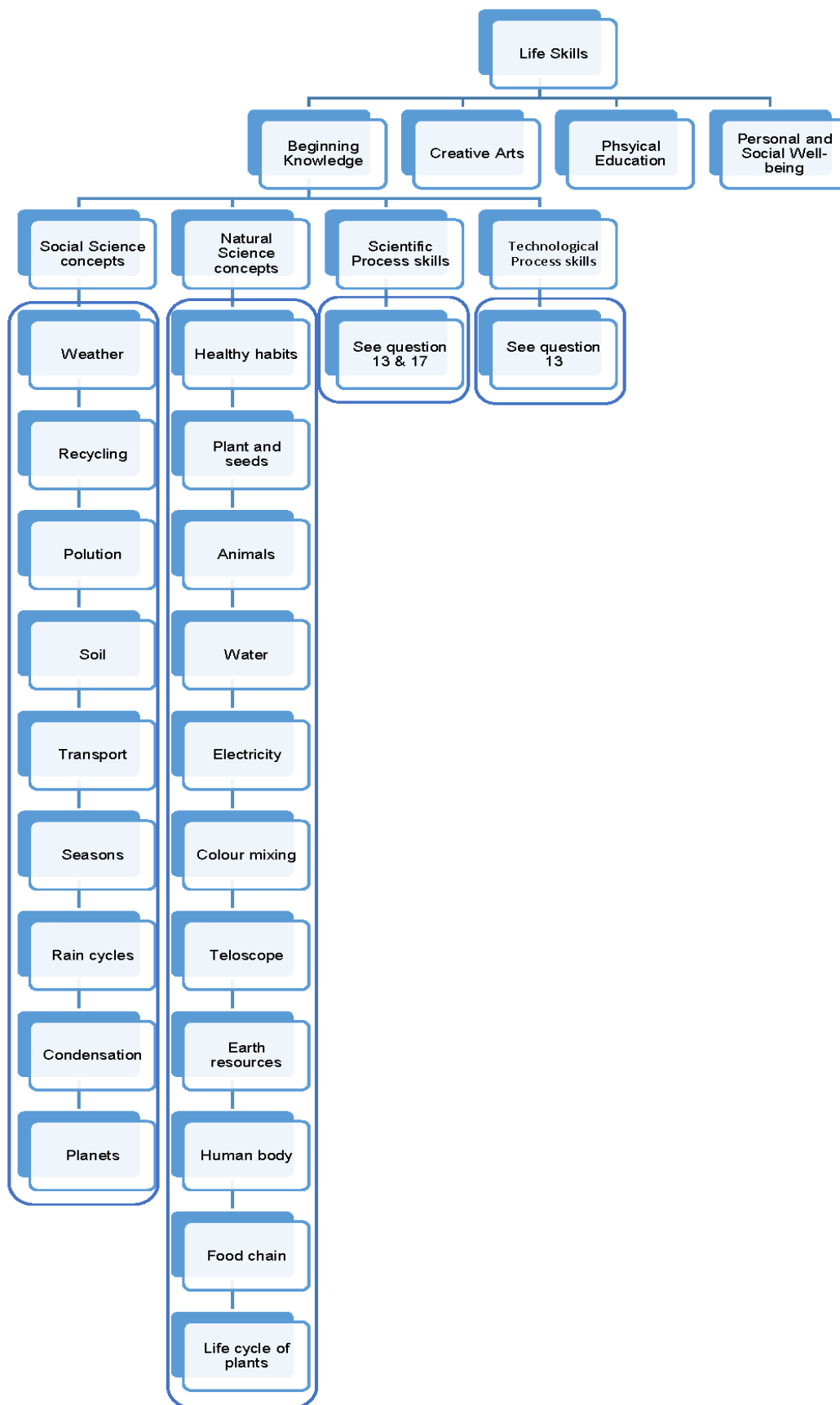


Figure 4-6: Topics addressed in Science (Life Skills – integrated subject)



Figure 4-7: Topics addressed in Mathematics

4.4.3 Question 12 of the adapted Creative Little Scientists questionnaire

Question 12 was “Please indicate your view on the importance of the following purpose of school SCIENCES (Science and Mathematics) in compulsory education (Grade R-12).” See Table 4-7 below for a breakdown of the Likert scale for the question.

Table 4-7: Purpose of Sciences in compulsory education

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. The purpose of Sciences in compulsory education				

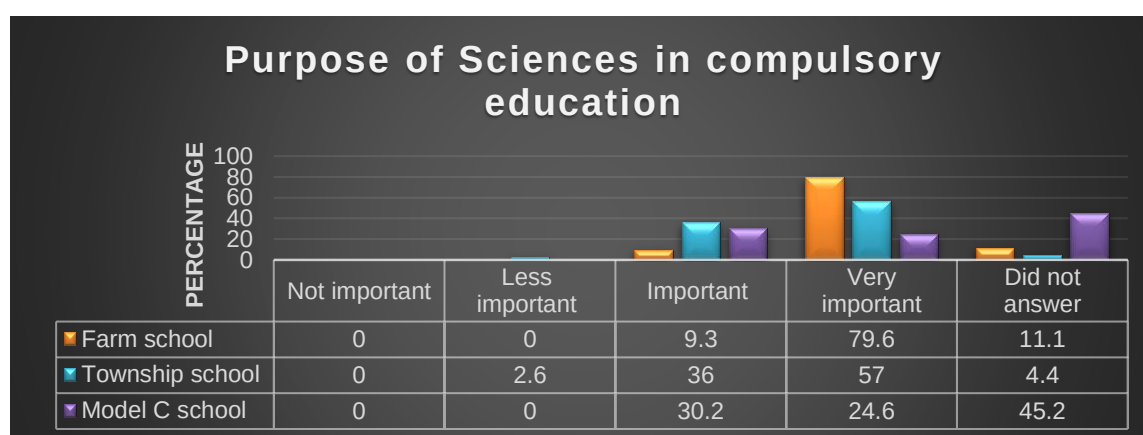


Figure 4-8: The importance of Sciences in compulsory education

Of the participating teachers, 20.2% opted not to answer the question on the importance of Sciences in compulsory education. The overall view of the remainder of the participants is that Science and Mathematics are important in compulsory education (see Figure 4-8).

The above results indicate that the teachers conceptualise the learning and learning activities of Mathematics and Science as a crucial part of compulsory education for learners in Grades R to 3 in South Africa.

4.4.4 Question 13 of the adapted Creative Little Scientists questionnaire

Question 13 was “Please indicate how often you foster the development of the following SCIENCE learning outcomes”. See Table 4-8 below for a breakdown of the sub-questions and the Likert scale.

Table 4-8: Fostering the development of SCIENCE learning outcomes

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To know and understand the important scientific ideas (facts, concepts, laws and theories)				
b. To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world				
c. To be able to communicate investigations and explanations				
d. To have positive attitudes to Science learning				

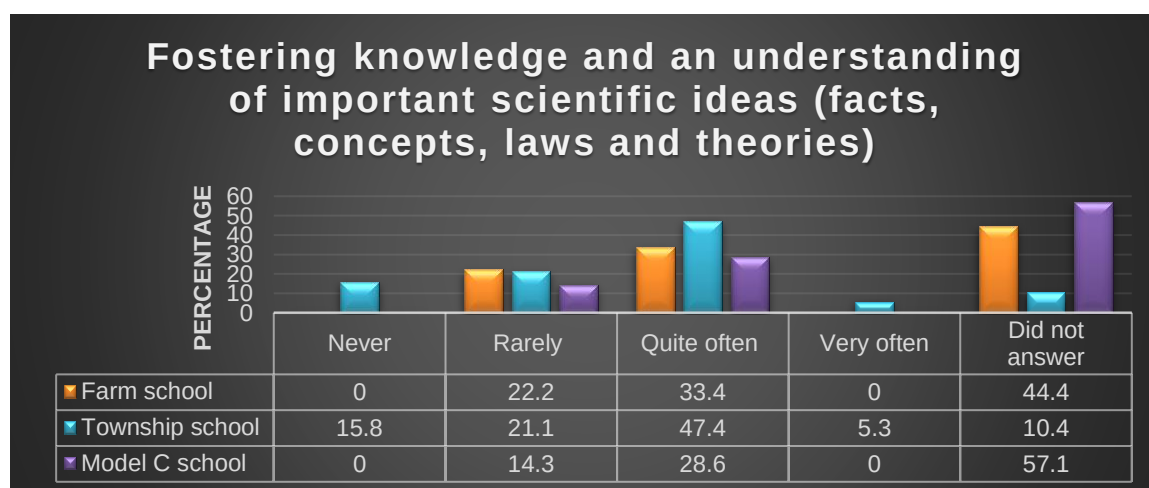


Figure 4-9: Fostering knowledge and an understanding of important scientific ideas

A total of 37.3% of the participating teachers opted not to answer the question. Of the remaining participants, 36.5% indicated that they fostered scientific ideas quite often. It is important to note that 19.2% of the participants reported that they rarely fostered scientific ideas (see Figure 4-9).

The ATP policy document of South Africa provides teachers in each Grade with a detailed breakdown of the weeks of each term with the CAPS topic, core concepts, skills and values, strategies of teaching, required pre-knowledge, a list of resources and the informal and formal assessment needed for the teaching and learning activities in that week (Department of Basic Education, 2021c:1-41). Because of the integrated structure of the learning areas within the Life Skills subject, this document provides teachers with the scientific ideas that learners should acquire under each of the CAPS topics (Department of Basic Education, 2021c:1-41).

The ATP policy document provides teachers with a CAPS topic for each week that includes a detailed breakdown of the knowledge that learners should acquire (Department of Basic Education, 2021c:1-41). The results from the questionnaire indicate that the teachers often foster knowledge and an understanding of important scientific ideas in learners.

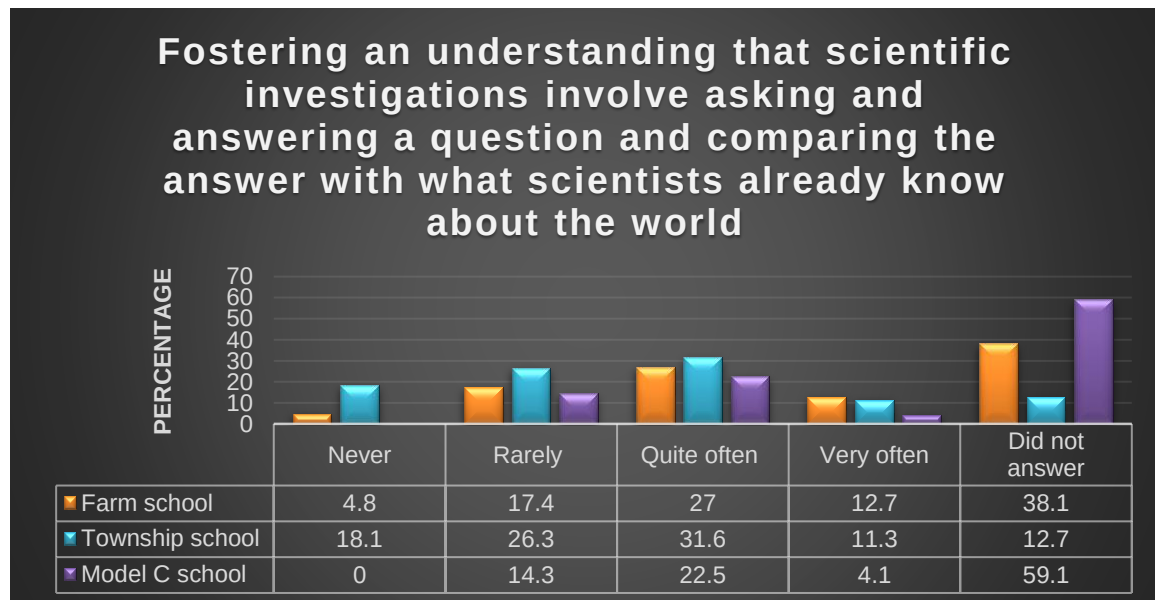


Figure 4-10: Fostering an understanding of scientific investigations

A total of 36.6% of the participating teachers opted not to answer the question. The remaining participants indicated that they fostered the skill of scientific investigation quite often (see Figure 4-10).

As mentioned in the above discussion, the ATP for Life Skills (integrated subject containing Science content) provides teachers with a list of skills and values that learners should acquire during the teaching and learning activities of a CAPS topic (Department of Basic Education, 2021c:11-22). An example of this is that Grade 3 learners (Term 2) need to inquire about, observe, compare and classify insects using knowledge of types of insects, body parts, characteristics and movement (Department of Basic Education, 2021c:11-22).

The policy document prescribes specific skills and values to be transferred to learners under each CAPS topic (Department of Basic Education, 2021c:11-22). The ATP indicates the topics per week. As different skills and values are required under the different CAPS topics, teachers are prescribed to often foster different methods of scientific investigation, including asking questions and comparing the answers to what is already known.



Figure 4-11: Fostering the ability to communicate in Science

Of the participating teachers, 33.7% opted not to answer the question. The remaining participants reported that they often fostered learners' ability to communicate data and findings (see Figure 4-11).

As mentioned in the previous discussion, the ATP provides a list of skills and values that learners should acquire during the teaching and learning activities of a CAPS topic (Department of Basic Education, 2021c:11-22). Communication falls under this list of skills and is set as a requirement for learners (Department of Basic Education, 2021c:11-22). Furthermore, according to the ATP, learners should be assessed on a weekly basis on an oral and practical level (Department of Basic Education, 2021c:11-22).

The teachers are of the perception that fostering of the ability to communicate, investigate and explain are methods that should often be used when teaching Science.

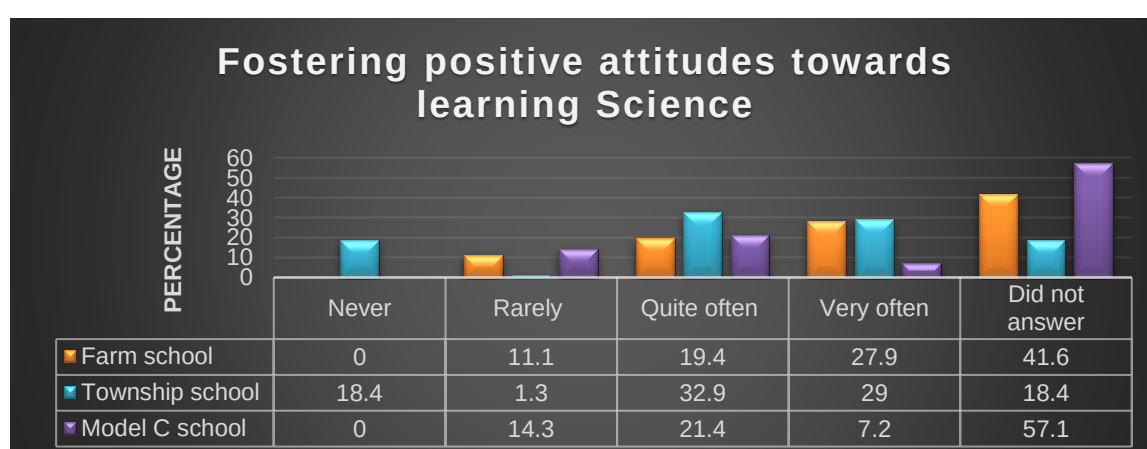


Figure 4-12: Fostering positive attitudes towards learning Science

A total of 39% of the participating teachers opted not to answer the question. The remaining participants reported that they often fostered a positive attitude towards learning Science (see Figure 4-12).

Although the ATP for Life Skills (integrated subject containing Science content) does not mention fostering a positive attitude towards learning Science as a part of the lesson content, mention is made of informally assessing learners' attitudes (Department of Basic Education, 2021c:11-22).

The overall perception of the teachers confirms that it is important to foster positive attitudes towards learning Science in learners in Grades R to 3.

4.4.5 Question 14 of the adapted Creative Little Scientists questionnaire

Question 14 was “**Please indicate how often you foster the development of the following MATHEMATICS learning outcomes**”. See Table 4-9 below for a breakdown of the sub-questions and the Likert scale.

Table 4-9: Fostering the development of Mathematics learning outcomes

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To know and understand the important mathematic ideas (facts, concepts, laws and theories)				
b. To understand that mathematic problem solving involve asking and answering a question and comparing the answer with what mathematicians already know about the world.				
c. To be able to communicate investigations and explanations				
d. To have positive attitudes to Mathematics learning.				

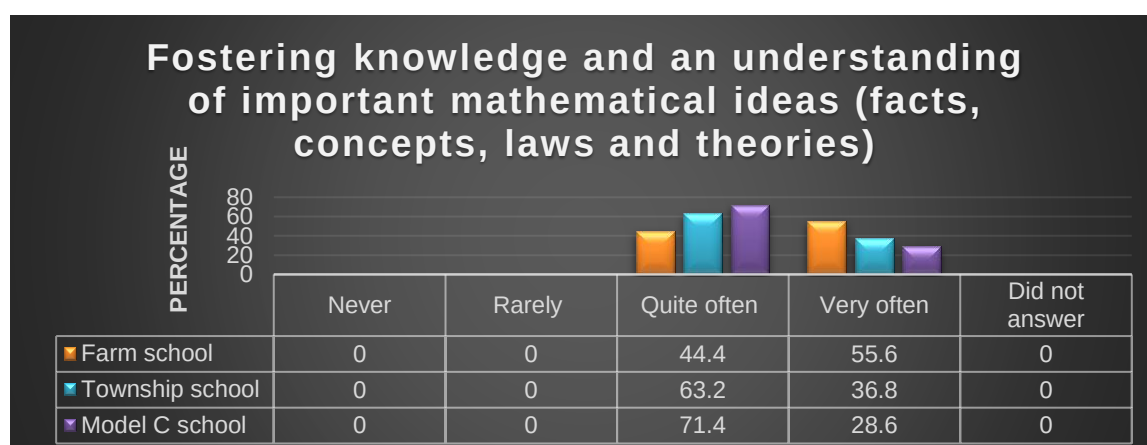


Figure 4-13: Fostering knowledge and an understanding of important mathematic ideas

All of the participants indicated that they often fostered knowledge and an understanding of mathematical ideas (see Figure 4-13).

The ATP provides teachers with a detailed list of core concepts that learners should acquire during the course of a week scheduled per term (Department of Basic Education, 2021a:1-2). These core concepts are also prescribed to be assessed informally or formally (Department of Basic Education, 2021a:1-2).

As the policy documents indicate the various concepts to be taught during each week of the term throughout the year, the results from the participants confirm that facts, concepts, laws and theories are often fostered.

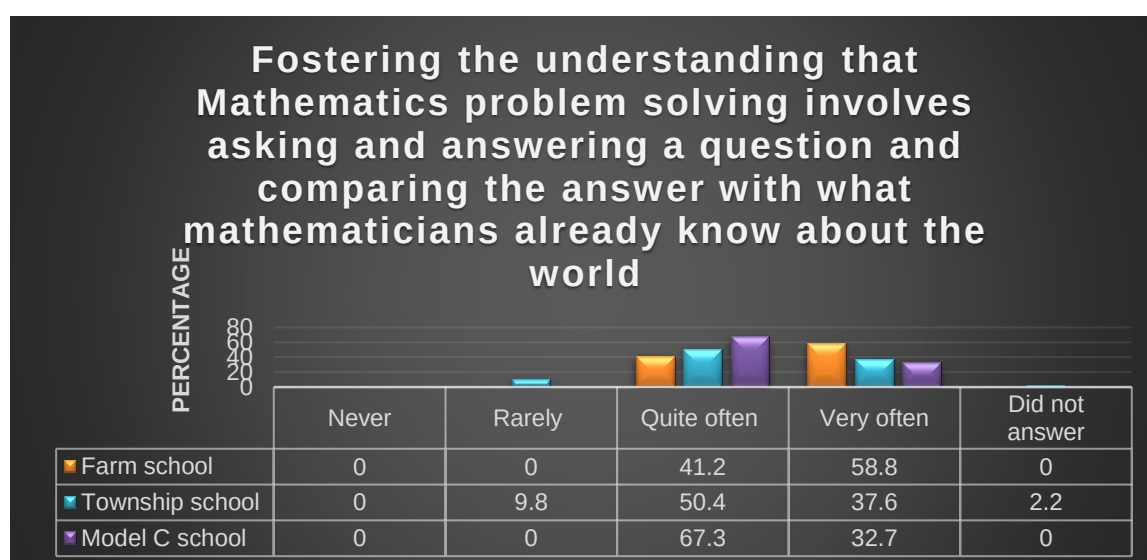


Figure 4-14: Fostering an understanding of mathematic problem solving

Of the participating teachers, 0.7% opted not to answer the question. The participants from all three types of schools indicated that they often fostered the understanding that Mathematics problem solving involves learners asking questions and then comparing the answers to what mathematicians already know (see Figure 4-14).

The ATP for Mathematics provides a list of core concepts that learners should attain during a week (Department of Basic Education, 2021a:1-2). These concepts can all be linked to the different types of knowledge as described by Piaget (1971) on how learners learn Mathematics concepts. The different types of knowledge are logical-mathematical, social-conventional and physical knowledge. Social-conventional knowledge has a close connection with language; the names of numbers or days fall under this type of knowledge. Logical-mathematical knowledge is constructed within a learner's mind, based on the foundation of physical and social-conventional knowledge. Physical knowledge entails what is known about objects, for example that a marble will roll (Piaget, 1971).

When teachers provide learners with context-type problems, the learners can solve these problems by using what they know about the world (what the teacher has taught them) in the context of that problem. The ATP policy document often prescribes making use of contexts when teaching different concepts (Department of Basic Education, 2021a:1-2).

The results from the participants support the idea that fostering the understanding of problem solving involves learners asking and answering questions, and then comparing the answers to what mathematicians already know takes place often.



Figure 4-15: Fostering the ability to communicate in Mathematics

The majority of the participants indicated that they often fostered learners' ability to communicate findings. The participants from Farm schools indicated that they fostered learners' ability to

communicate findings more often than the participants of the other types of schools (see Figure 4-15).

Although the ATP does not provide teachers with a list of skills and values that learners should attain, but instead, the core concepts to be addressed when teaching Mathematics, the document does prescribe the informal and formal oral assessment of learners in Grades R to 3 (Department of Basic Education, 2021a:1-2).

The assessment of Grade R learners, according to the SBA policy document, is done by teachers using only observations (Department of Basic Education, 2018c:7). The learners are given daily oral or practical activities that are then assessed by their teachers (Department of Basic Education, 2018c:7). The policy document provides checklists and rubrics as guidelines for assessing (see Tables 4-15 and 4-21).

Unlike the Grade R assessment, the SBA policy document provides teachers who teach Grades 1 to 3 with a timeline and guidelines for written, oral, practical and observation activities (Department of Basic Education, 2018b:42). Most of these activities require learners to complete written tasks that are assessed based on a memorandum. Oral and practical activities, as seen in Table 4-22, require teachers to record the results by making use of checklists or rubrics. (See Tables 4-23 and 4-24 for examples of checklists and rubrics.)

As seen in the results of the data gathered from the participants and the policy documents, teachers often have to foster learners' abilities to communicate their investigations and explanations, as this prepares them for both informal and formal oral assessment.

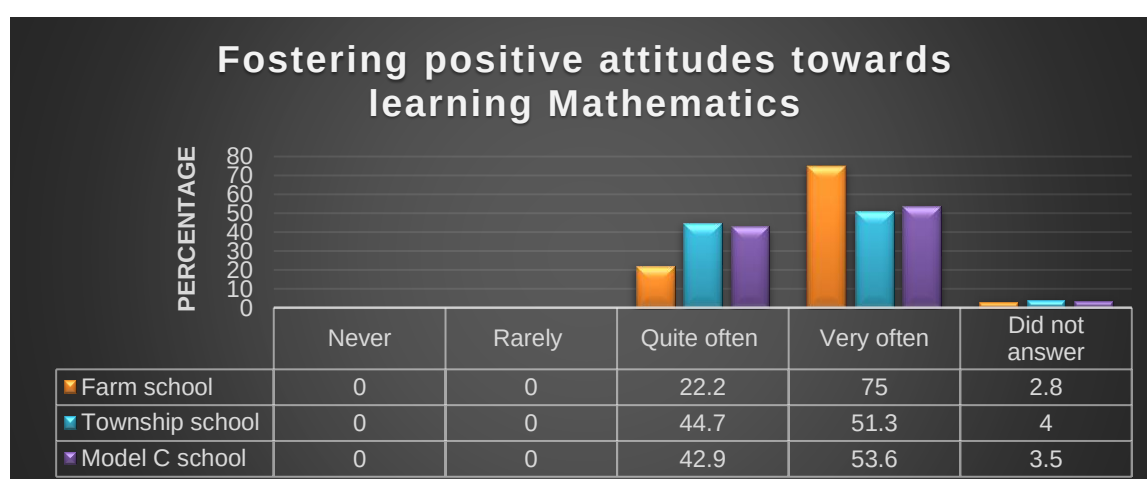


Figure 4-16: Fostering positive attitudes towards Mathematics learning

Of the participating teachers, 3.4% opted not to answer the question. The remainder of the participants indicated that they often fostered positive attitudes towards learning Mathematics in learners. The participants from the Farm schools indicated that they fostered positive attitudes towards learning Mathematics more often than the participants from the other types of schools (see Figure 4-16).

The policy documents do not mention fostering a positive attitude towards learning Mathematics. Although the policy does not mention this matter, the teachers still maintained the impression that they should often support a positive attitude towards Mathematics in learners.

4.4.6 Summary of the pedagogical phenomenon of connect and curriculum

A summary of the results that emanated from Questions 10, 11, 12, 13 and 14 in the adapted Creative Little Scientists questionnaire indicated i) the amount of time dedicated to teaching Science and Mathematics, ii) an indication of some of the content taught within Science and Mathematics by the participants and iii) the perception of the teachers regarding the importance of fostering knowledge and an understanding of Science and Mathematics, as well as communication in and a love for Science and Mathematics in young learners in accordance with policy.

- i. The overall results from all three types of schools indicate that the teachers spend more time teaching Mathematics than Science. The time allocation for Mathematics corresponds with the prescribed time in the policy documents, whereas the time allocation for Science does not correspond with the prescribed time in the policy documents (Department of Basic Education, 2011a:6).
- ii. The teachers indicated multiple content topics under the five learning areas of Mathematics. Furthermore, teachers provided content topics that formed part of Beginning Knowledge (integrated learning area consisting of content from Social Science concepts, Natural Science concepts, Scientific Process skills and Technological Process skills) as part of Life Skills (Department of Basic Education, 2011a:8). The CAPS policy document prescribes what content is to be taught per Grade in both Life Skills and Mathematics. This is supported by the ATP policy document that provides teachers with a timeline and a more detailed breakdown of what content is to be taught and when (Department of Basic Education, 2021a:1-3; 2021c:14-22). The ATP policy document for Life Skills provides teachers with a clear indication of the CAPS topics that fall under Beginning Knowledge (Department of Basic Education, 2021c:14-22). Due to the integrated nature of the Life Skills subject, however, teachers are prescribed and encouraged to use a CAPS topic as context for all of the learning areas of Life Skills.

- iii. Lastly, the overall results from all three types of schools indicate that the teachers hold the perception that knowledge, understanding, communication and a positive attitude in terms of both Science and Mathematics should be fostered in young learners. Both the Life Skills and Mathematics policy documents provide teachers with the prescribed knowledge that learners should have attained at the end of each Grade (Department of Basic Education, 2021a:1-3; 2021c:14-22). The Life Skills policy document provides teachers with a list of skills and values that teachers should foster within learners under each CAPS topic (Department of Basic Education, 2021c:14-22). The Mathematics policy document, however, places the main focus on core concepts that learners must develop, rather than skills and values (Department of Basic Education, 2021a:1-3).

It is important to note that the policy documents regarding Mathematics are very clear and concise as guidelines for teaching and learning activities. Due to the integrated nature of Life Skills, the incorporation of a CAPS topic in all four of the learning areas is prescribed, but the instructions provided are somewhat vague. The integrated nature of Life Skills and the use of learning area names such as “Beginning Knowledge”, “Creative Arts”, “Physical Education” and “Personal and Social Well-being” can explain why the participants indicated that they did not teach a subject called “Science”. From the discussions of Questions 10, 11 and 13, however, it is clear that Science is an integrated component of Life Skills and that all of the participants teach concepts from the Science domain in Grades R to 3.

4.5 Pedagogical phenomenon: assessment

The following questions from the adapted Creative Little Scientists questionnaire provide data supporting the pedagogical phenomenon of assessment in South Africa: Questions 22 (the teacher’s view on the importance of assessment of Science in the age group that he or she teaches), 23 (the teacher’s view on the importance of the assessment of Mathematics in the age group that he or she teaches), 24 (how often the teacher assesses learners in Science using artefacts, relevant gestures, physical activity or verbal feedback), 25 (how often the teacher assesses learners in Mathematics using artefacts, relevant gestures, physical activity or verbal feedback), 26 (how often the teacher rewards or praises learners in the Science class), 27 (how often the teacher rewards or praises learners in the Mathematics class), 28 (how often the teacher assesses learners to determine their progression, development and improvement in Science) and 29 (how often the teacher assesses learners to determine their progression, development and improvement in Mathematics).

4.5.1 Question 22 of the adapted Creative Little Scientists questionnaire

Question 22 was “Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of learners ASSESSMENT in SCIENCE education. To assess the development of learners”. See Table 4-10 below for a breakdown of the sub-questions and the Likert scale.

Table 4-10: Assessment for development priorities in Science education

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of scientific ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of scientific processes				
c. Positive attitudes and increase of interest in learning Science				

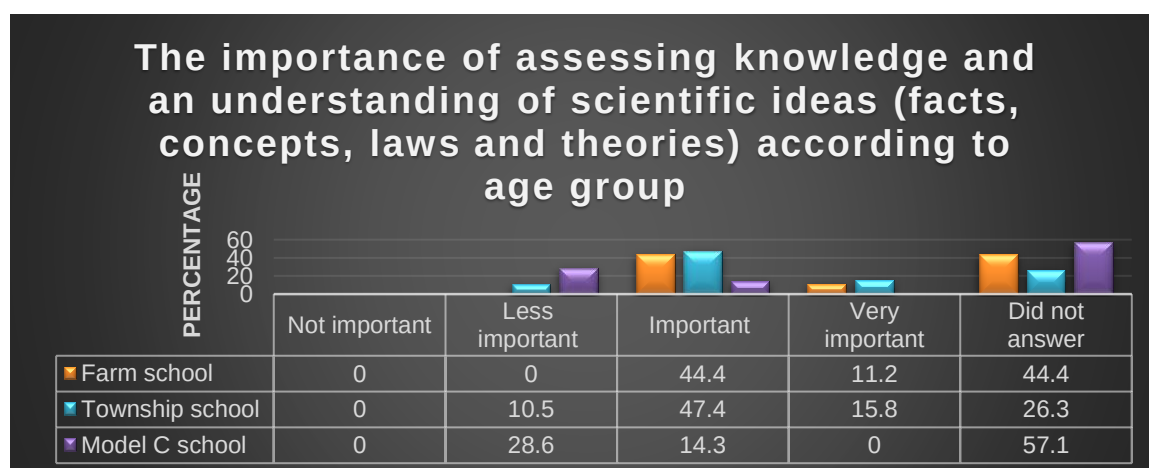


Figure 4-17: Assessment of learners’ knowledge and understanding of scientific ideas

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that it was important to assess learners’ knowledge and understanding of scientific ideas in Grades R to 3 (see Figure 4-17).

The Life Skills (integrated subject containing Science content) ATP policy document provides teachers with the CAPS topic to be covered during a term (Department of Basic Education, 2021c:11-22). Under each CAPS topic, the teacher is provided with a list of informal and formal assessments for the topic (Department of Basic Education, 2021c:11-22). The SBA policy

document provides teachers with the content, forms of assessment and assessment tools to be used for informal and formal assessment (Department of Basic Education, 2018b:3). The ATP and SBA policy documents provide teachers with the needed information and timelines to assess learners on a CAPS topic daily, weekly or per term. The perception of the teachers is that it is important to assess learners' knowledge and understanding of scientific ideas.

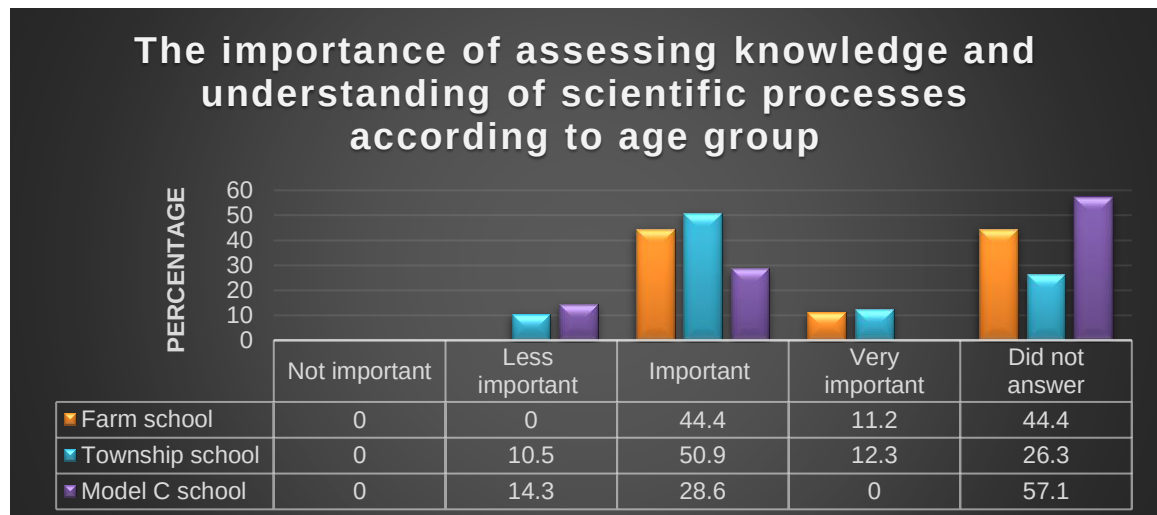


Figure 4-18: Assessment of learners' knowledge and understanding of scientific processes

Altogether 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that it was important to assess learners' knowledge and understanding of scientific processes in Grades R to 3 (see Figure 4-18).

The ATP for Life Skills (integrated subject containing Science content) lists skills and values that learners should acquire or practise under each of the CAPS topics (Department of Basic Education, 2021c:11-22). Informal assessment of learners in an oral or practical task is suggested for assessing these skills (Department of Basic Education, 2021c:11-22). Although the policy documents do not require teachers to record the outcomes of the informal assessment of learners' knowledge and understanding of scientific processes, the teachers perceive this assessment as important.

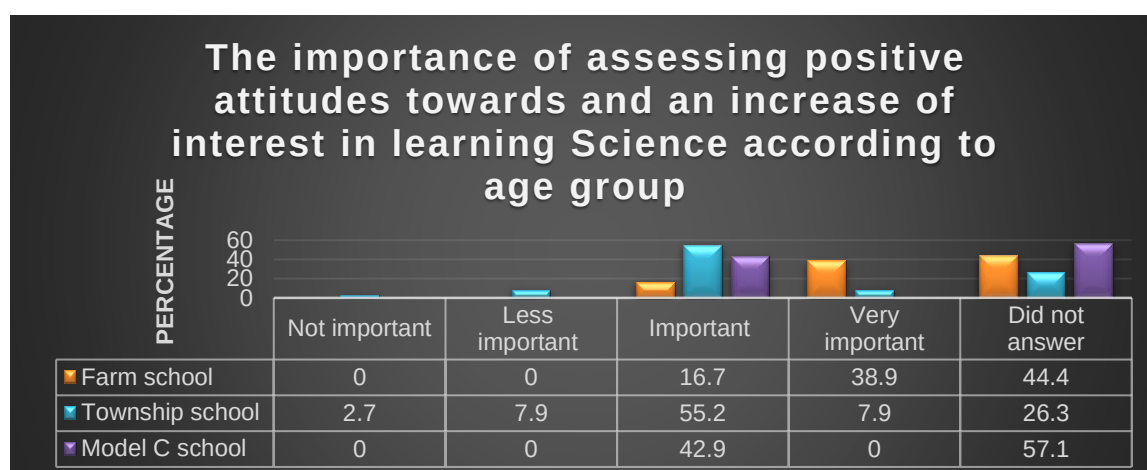


Figure 4-19: Assessment of learners' attitudes towards and interest in learning Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that their perception was that it is important to assess learners' attitudes towards and interest in learning Science (see Figure 4-19).

Although the policy documents do not provide guidelines on assessing learners' attitudes and interest, the teachers see the importance of assessing learners' attitudes towards and interest in learning Science.

4.5.2 Question 23 of the adapted Creative Little Scientists questionnaire

Question 23 was **"Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of learners ASSESSMENT in MATHEMATICS education. To assess the development of learners"**. See Table 4-11 below for a breakdown of the sub-questions and the Likert scale.

Table 4-11: Age group priorities in Mathematics education

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of Mathematics ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of mathematic processes				
c. Positive attitudes and increase of interest in learning Mathematics				

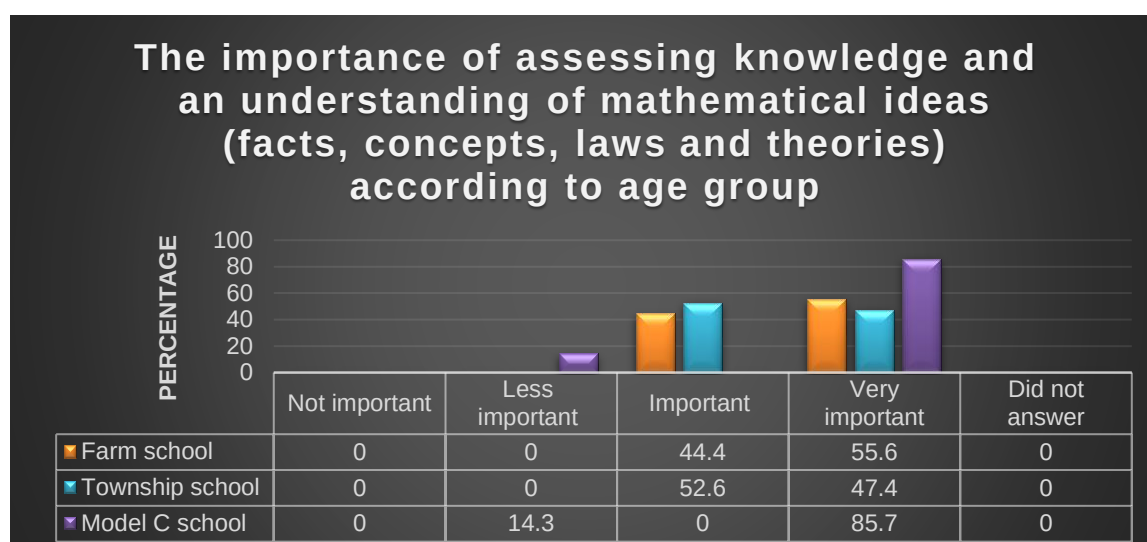


Figure 4-20: Assessment of learners' knowledge and understanding of Mathematic ideas

The participants agreed that it was important to assess learners' understanding and knowledge of Mathematic ideas. The participants from the Model C school indicated a stronger belief in the importance of assessing learners' understanding and knowledge of Mathematic ideas than the participants from the other schools (see Figure 4-20).

The ATP policy document for Mathematics provides teachers with a detailed teaching and learning plan for each grade throughout the year (Department of Basic Education, 2021a:1-3). The curriculum content to be covered in a specific week is described to teachers, including core concepts, skills and values, strategies for teaching, prerequisite knowledge, resources and informal and formal assessments for the topic (Department of Basic Education, 2021a:1-3). The ATP policy document is supported by the SBA policy document that provides teachers with the content, forms of assessment and assessment tools (Department of Basic Education, 2018b:42; 2018c:7). All learners in Grades R to 3 complete either oral, practical or written Mathematic activities that are assessed to determine their understanding of mathematic ideas (Department of Basic Education, 2018b:42; 2018c:7).

As seen in the above discussion, the policy documents describe three types of assessment of learners' understanding and knowledge of Mathematic ideas. These assessments are prescribed to take place on a daily or weekly basis. The prescriptions of the policy together with the results from the teachers support the indication that the assessment of learners' Mathematical knowledge takes place often.

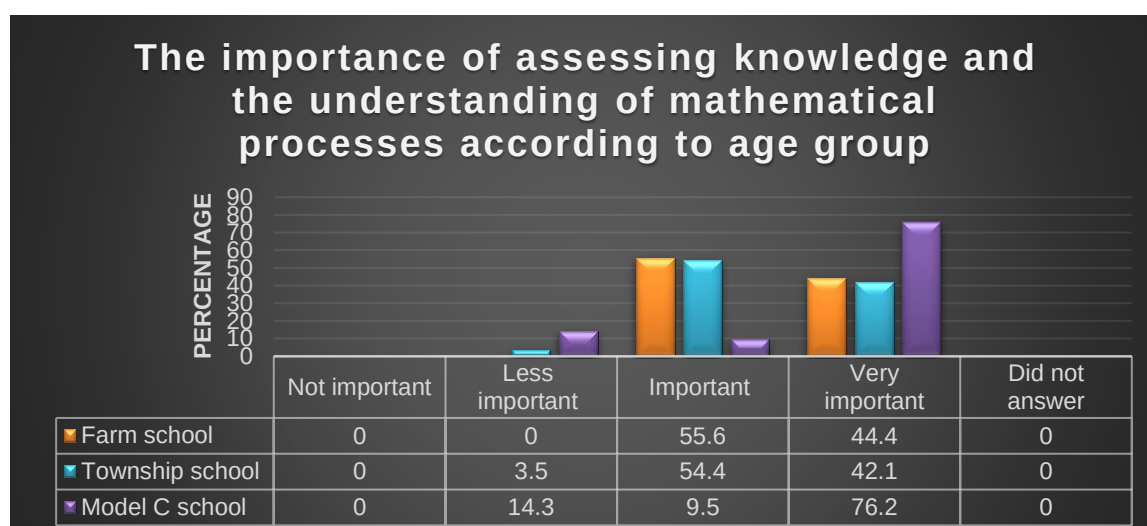


Figure 4-21: Assessment of learners' knowledge and understanding of Mathematic processes

The participants agreed that it was important to assess learners' understanding and knowledge of Mathematic processes in Grades R to 3. The participants from the Model C school indicated a stronger belief in the importance of assessing learners' understanding and knowledge of Mathematic processes than the participants from the other schools (see Figure 4-21).

The ATP for Mathematics provides a list of strategies that teachers are encouraged to use when teaching specific content to learners (Department of Basic Education, 2021a:2). These strategies prescribe specific processes that learners should use when completing activities. The SBA policy document for Mathematics provides a checklist or rubric for formal and informal assessment of learners' understanding of these processes (Department of Basic Education, 2018a:51-55).

Policy documents prescribe formal and informal assessment of learners either daily, weekly or per term. The teachers perceive the assessment of learners' understanding and knowledge of Mathematics processes as important in their teaching and learning activities.

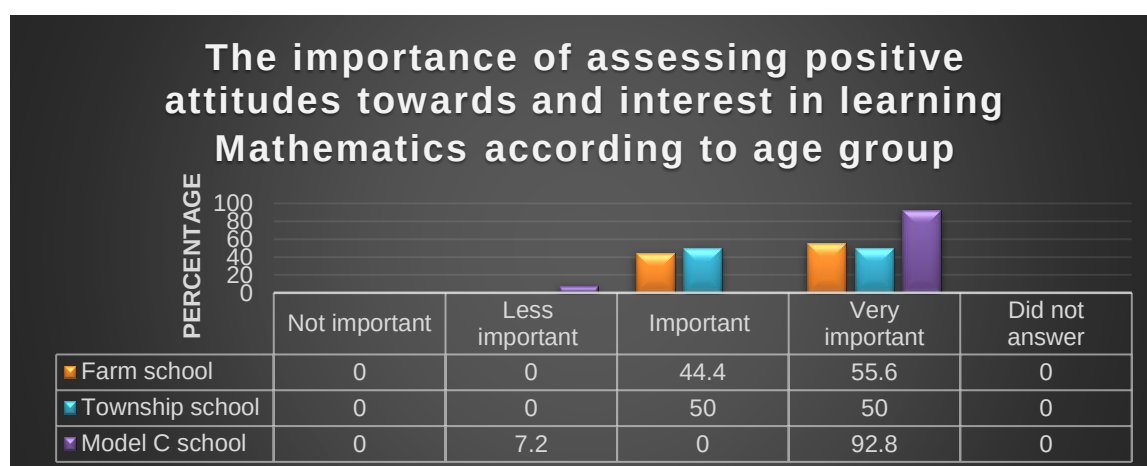


Figure 4-22: Assessment of learners' attitudes towards and interest in learning Mathematics

The participants agreed that it was important to assess learners' attitudes towards and interest in learning Mathematics. The participants from the Model C school indicated a stronger belief in the importance of assessing learners' attitudes towards Mathematics than the participants from the other schools (see Figure 4-22).

While the ATP for Mathematics lists a section with core concepts, skills and values that need to be addressed within the subject content of Mathematics, this policy document focuses only on listing the core concepts prescribed and does not provide teachers with a list of values and skills to be fostered in learners (Department of Basic Education, 2021a:1).

Although none of the policy documents references the assessment of learners' attitudes, the teachers see the importance of assessing learners' positivity towards and interest in learning Mathematics.

4.5.3 Question 24 of the adapted Creative Little Scientists questionnaire

Question 24 was "How often do you assess your learners in SCIENCE in the following ways?". See Table 4-12 below for a breakdown of the sub-questions and the Likert scale.

Table 4-12: Assessment in Science

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Evaluating learners classroom artefacts which show their scientific reasoning				

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
b. Evaluating learners relevant gestures or physical activity				
c. Asking each learner to provide verbal feedback				
d. Using formal assessment				

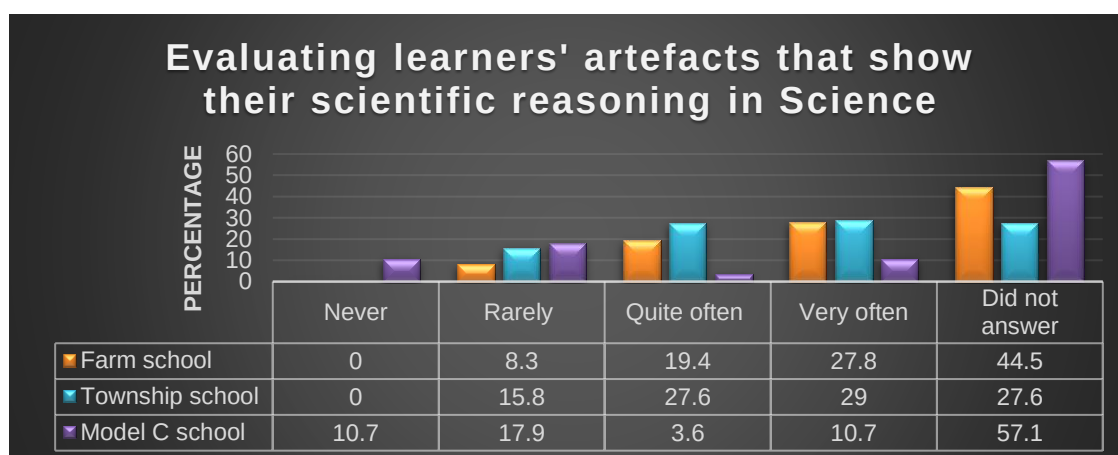


Figure 4-23: Evaluating learners' artefacts in Science

Of the participating teachers, 43.1% opted not to answer the question. The remaining participants from the Farm and Township schools indicated that they often assessed learners' classroom artefacts, while the participants from the Model C school indicated that they rarely assessed learners' classroom artefacts (see Figure 4-23).

Learners' artefacts refer to any work that a learner has completed in written or visual form. Scientific reasoning refers to a problem-solving process in relation to content and processes.

The ATP policy document for Life Skills (integrated subject containing Science content) provides the teacher with general guidelines and timelines for assessment under each learning area (Department of Basic Education, 2021c:11-22). While the document refers to formal and informal assessment, only informal assessment activities are listed in the ATP and teachers are referred to the SBA policy document for details on formal assessment (Department of Basic Education, 2021c:11-22). The SBA policy document provides teachers with a list of the knowledge, skills and values that need to be assessed and the type of assessment that needs to take place. A rubric and a checklist are included as well. See Tables 4-13 to 4-18 for examples from the SBA policy documents (Department of Basic Education, 2018b:42, 43, 45; 2018c:7, 9, 11).

Grade R learners, according to the SBA policy document, are only assessed based on observations (see Table 4-13 below) made by the teacher of oral and practical work using

checklists (see Table 4-14 below) and rubrics (see Table 4-15 below) (Department of Basic Education, 2018c:7). As seen in Table 4-13 below, extracted from the SBA policy document, teachers observe (using rubrics and checklists) Grade R learners' interaction within physical movement and their language instead of artefacts in a written or visual form.

Table 4-13: Extracted example of SBA assessment plan for Grade R Life Skills (Department of Basic Education, 2018c:7)

Term 1: Life Skills Grade R							
Acti- vities	Skills for informal assessment	Forms of assessment	Assessment tool	Assessment method	Score	Date to be completed	Date com- plete d
1	Participates and engages in discussions related to topics (Beginning Knowledge & Personal and Social Well-being)	Observation	Rubric 1	Practical / Oral	3	On or before the end of the term	
2	Exploring music, movement and voice focusing on tempo: fast and slow		Checklist	Practical/ Oral	n/a		
3	- identifies parts from the whole such as names and points to parts of the body - identifies and name body part		Rubric 2	Oral	3		
4	Locomotor: walk and run in different directions without bumping into each other, running on all fours, running around a marker		Rubric 3	Practical	3		
5	Balance: balancing on a balancing beam/skipping rope/masking tape, walking forwards and backwards		Checklist	Practical	n/a		
6	Coordination: throwing and catching beanbags, jungle gym: climb a ladder		Checklist	Practical	n/a		
General and perceptual Development The skills in the general and perceptual development checklist should be assessed continuously and reported to parents quarterly. The checklist is to be used for close recording and kept in the teacher's assessment file.			Checklist	Practical	n/a		
Teacher notes: The above skills will be observed during the integrated daily programme. Many skills are integrated in Home Language, Mathematics and Life Skills and cannot be separated in Grade R. All skills listed are not meant to be an assessment activity but rather you ensure that your learners are afforded many opportunities to learn and practise the skills demonstrated in many ways. The skills listed below are taught but do not appear on the checklist or rubric. • Uses language to give explanations • Develops language to develop concepts for shapes, colour and age • Draws and paints freely • Sings and recites simple songs and rhymes • Rhythm: jumping with feet together or alternate feet • Rhyme: use sense of hearing							

Term 1: Life Skills Grade R							
Activities	Skills for informal assessment	Forms of assessment	Assessment tool	Assessment method	Score	Date to be completed	Date completed
By the end of the term (or week 9) you should be able to complete the checklist and score each learner according to the rubric.							

Table 4-14: Extracted example of SBA rubric for Grade R Life Skills (Department of Basic Education, 2018c:11)

Life skills: Rubric 1: Participates and engages in discusses related to Topics (Beginning Knowledge & Personal and Social Well-being)

3	Participates actively and contributes in discussions
2	Participates and discusses when supported by teacher
1	Unable to participate and is reluctant to contribute during discussions

Life skills: Rubric 2: Identifies names and points to parts of the body

3	Identifies, names and points at least 10 the body parts correctly: eye, ears, mouth, nose, hands, head, legs, feet, toes, fingers, hair, tongue, stomach, lip, elbows and anything else added by the learner.
2	Identifies, names, points and touch at least 7-8 of the basic body parts (eye, ears, mouth, nose, hands, head, legs and feet).
1	Identifies only 5 -6 of the basic body parts (eye, ears, mouth, nose, hands, legs). Can name these by pointing /touching them. Unsure of the other more detailed body parts such as elbow etc.

Life skills: Rubric 3: Locomotor: walk and run in different directions without bumping into each other, running on all fours, running around a marker

3	Very good at walking and running in different directions without bumping into each other. Enjoys running on all 4s. Excellent when running around markers, hands and feet move rhythmically.
2	Is starting to get confident when walking and running in different directions. Starts running on all 4s and around markers, hands and feet don't always follow each other rhythmically.
1	Struggles to walk and run in different directions without bumping into each other. Cannot run on all 4s nor around a marker, hands and feet do not move together rhythmically.

Table 4-15: Extracted example of SBA checklist for Grade R Life Skills (Department of Basic Education, 2018c:9)

Checklist: Term 1								
Subject		Home Language	Mathematics			Life Skills		
✓ - achieved ✗ - not yet • - almost		Distinguishes aurally between different letter sounds especially at the beginning of own name	Describes, sort and compares 3D objects about according to shape. Able to collect and sort draw, read and represent objects according to one attribute	Knows on, in, out, up, down Understands backwards, forwards, front, back	Recognise, identifies 3 D objects e.g. balls, boxes	Exploring music, movement and voice focusing on tempo : fast and slow	Balance: balancing on a balancing beam/ skipping rope/ masking tape walking forwards and backwards	Coordination: throwing and catching beanbags. Jungle gym: climb a ladder
Date								
Learners names								
1								
2								

Unlike the assessment in Grade R, the SBA policy document provides teachers teaching Grades 1 to 3 with a timeline and guidelines for written, oral, practical and observation activities (Department of Basic Education, 2018b:42). Some of the activities require learners to complete written and visual artefacts that can be assessed as seen examples of a checklist and a rubric).

Table 4-16: Extracted example of SBA assessment plan for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:42)

Life Skills – Programme of assessment: Grade 3 Term 2							
Study area	Topic	What will be assessed?	Forms of assessment	Assessment tools	Score	Date to be completed	Date completed
Beginning Knowledge and Personal and Social Well-being	Healthy eating	Knowledge of the different food groups and a balanced diet	Oral/Practical Written	Rubric & Checklist Poster	5	By week 3	
	Insects	Creates and designs a Big Book on insects showing: • characteristics of the insect • different insects • how insects help us • how insects harm us	Oral/Practical Written	Rubric & Checklist Big Book	5	By week 6	
	Life cycles	Makes a poster/storyboard on the life cycle of an animal of his/her choice	Oral/Practical Written	Rubric & checklist Storyboard/Poster	5	By the end of the Term	
	Recycling	Knowledge of: • recycling, reusing and reducing waste • making compost • re-using water	Oral & Practical	Checklist	n/a		
Performing arts	Improvise and interpret: Dramatisation	Dramatises short story scenes in groups	Oral & Practical	Rubric & Checklist	5		
Visual Arts 2D & 3D	Create in 3D	Makes a 3D box sculpture	Observation & Practical	Rubric & Checklist	5		
Physical Education	Spatial orientation	Spatial orientation: dribbling and passing skills	Observation & Practical	Rubric & Checklist	5		
Total score							30
Scores will be captured on SASAMS. The score will be converted to a percentage to indicate level 1-7 for the report card.							
Teacher notes: The content relating to Life Skills topics will be assessed during the daily lessons. Exemplar checklists and rubrics will be used to record and report on each learner's progress at the end of each term. Where possible, teachers are encouraged to ensure that the assessment activities are integrated across the Life Skills study areas, and also, where possible, these assessment activities should be integrated with Languages and Mathematics lessons. Physical Education: spatial orientation: Learners should be assessed at one station only for this activity (1-2 groups should be assessed in a 1-hour lesson) and this activity should be done over a period of 4 to 5 weeks to ensure that all learners in the class are assessed on dribbling and passing skills.							

Table 4-17: Extracted example of SBA rubric for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:45)

LIFE SKILLS: RUBRIC: GRADE 3: TERM 2					
Beginning knowledge & Personal and Social Well being					
Activity	1	2	3	4	5
Poster : 5 Basic Food Groups	Represents 1 basic food group using pictures	Represents 2 basic food groups using pictures with captions	Represents 3 basic food groups using pictures with captions and 1 short sentence on each food group	Represents the 4 basic food groups using pictures and drawings with captions and 2 short sentences on each food group	Represents the 5 basic food groups using own drawings , pictures and photographs with captions and 3 short sentences on each food group
Makes a poster/Storyboard on the life cycle of an animal of his/her choice.	The learner attempts to create the life cycle of his/her chosen animal.	The learner creates a poster reflecting the life cycle of his/her chosen animal.	The learner makes a poster/Storyboard reflecting the life cycle of his/her chosen animal. Labelling each of the stages.	The learner makes a poster/Storyboard reflecting the life cycle of his/her chosen animal. Labelling each of the stages and writes 1 fact for each stage	The learner makes a poster/ Storyboard reflecting the life cycle of his/her chosen animal. Labelling each of the stages and writes 2 facts for each stage
Make Big Book: Insects	Draws and writes 2 words for 1-2 pages of a Big Book	Makes a Big Book of 3-4 pages in a group with illustrations and two words on each page	Makes a Big Book of 5-6 pages in a group with colourful illustrations and 1 sentence on each page	Makes a Big Book of 7-8 pages in a group with colourful illustrations and 2 complex sentences on each page	Makes a Big Book of 9-10 pages in a group with colourful illustrations and 3 complex sentences on each page
Performing Arts					
Activity	1	2	3	4	5
Improvise and Interpret Dramatise short story scenes in groups	Participates in the group and retells some of the dialogue with support	In a group of 6 dramatises 1-2 scenes from a short story using props(masks/costumes) to depict characters and attempts to role play dialogue	In a group of 6 dramatises 3 scenes from a short story using props(masks/costumes) to depict characters and role plays dialogues	In a group of 6 dramatises 4 scenes from a short story using props(masks/costumes) to depict characters and uses expressive language to role play dialogues and gestures	In a group of 6 dramatises 5 scenes from a short story using props(masks/costumes) to depict characters and uses expressive language to role play dialogues and appropriate gestures and facial expression
Visual Arts					
Activity	1	2	3	4	5
Make a 3 D Box sculpture with recycled small boxes	Wraps a recycled box using coloured paper.	Makes a stack of 2 recycled boxes resembling a 3 D Box sculpture and decorates it with picture cut outs and a colours in the background	Makes a stack of 3 recycled boxes resembling a 3 D Box sculpture and decorates it with picture cut outs and paints the background	Makes a stack of 4 recycled boxes resembling a 3 D Box sculpture and decorates it with glossy picture cut outs and a paints a colourful background	Makes a stack of 5 recycled boxes resembling a 3 D Box sculpture and decorates it with glossy recycled wrappings and picture cut outs and a paints a colourful background

Table 4-18: Extracted example of SBA checklist for Grades 1 to 3 Life Skills (Department of Basic Education, 2018b:43)

LIFE SKILLS: CHECKLIST: GRADE 3: TERM 2														
Study Areas		Beginning Knowledge & Personal and Social Well being				Creative Arts				Physical Education		Comments		
						Performing Arts			Visual Arts					
Skills to be assessed		Knows the different types of food groups	Knows about the different types of insects and how they help us	Knows about harmful insects	Knows about the life cycle of some mammals, insects, amphibians and birds	Knows about recycling reducing and reusing of waste materials	Can do loco motor and non-loco motor movements	Demonstrates sensory awareness and performs rhythmic games	Perform notated rhythm patterns using body percussion movements	Make loose constructions, masks , puppets, with recycled materials and models with clay	Describe basic art elements using art vocabulary	Play traditional, indigenous and mini cricket and mini tennis skills	Demonstrate gymnastic and rhythmic movements using apparatus	
KEY: ✓ Achieved ● In need of support × Not achieved														
Date														
Learner's names														
1														
2														

There is a difference in how often the participants from the different types of schools assess artefacts when dealing with Science content. The prescribed policy may contribute to how often learners are assessed. There is a major difference between the type of assessment prescribed for Grade R learners and for learners in Grades 1 to 3. The Grade R curriculum is designed as play-based activities where learners are assessed through the use of practical and oral activities

that do not provide artefacts. Learners in Grades 1 to 3 are assessed on some artefacts, but with most of the focus on representing facts and little focus on scientific reasoning (see Tables 4-16, 4-17 and 4-18 above).

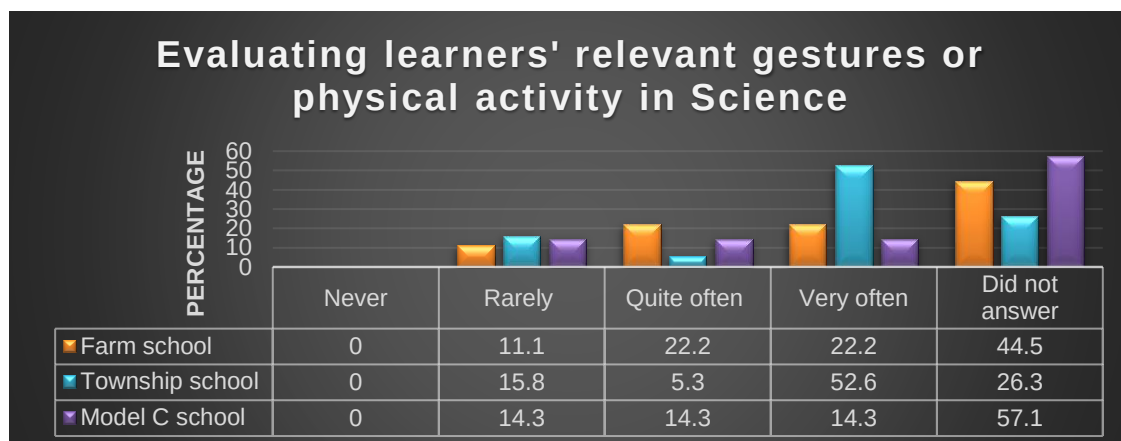


Figure 4-24: Evaluating learners' gestures or physical activity in Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that they often assessed learners' gestures or physical activity in Science (see Figure 4-24).

It is important to note that the content of Science falls under the subject of Life Skills, as mentioned above (see Section 4.4.1). The Life Skills subject consists of four learning areas Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being (Department of Basic Education, 2011a:8-9). The CAPS and ATP policy documents encourage teachers to use a CAPS topic, such as insects, and design teaching, learning and assessment activities in each of the four learning areas about this topic. For example, learners can engage in Beginning Knowledge activities such as learning the characteristics of insects, in Creative Arts activities such as drawing and painting insects along with stories and rhymes and in Physical Education activities such as walking like insects (Department of Basic Education, 2021c:11-22). The learners are assessed based on the activities within each of the learning areas or within an integrated activity such as the Big Book that they can design and create based on the characteristics of insects (see Table 4-16). This book needs to have colourful art illustrations of the insects (see Table 4-17). The book, furthermore, has to include a story about the insects (see Table 4-17). The Physical Education learning area is not assessed in this example.

As mentioned in the discussion above, the Grade R curriculum is structured with a focus on play-based activities, and Grade R learners are assessed only by using observations done by the

teachers (Department of Basic Education, 2018c:6). Learners are introduced to Science topics in the subject of Life Skills throughout their Grade R year, for example weather, transport and animals. The assessment plan, rubrics and checklists provided in the SBA policy document indicate that Grade R learners are observed and assessed on their practical execution of play-based activities (Department of Basic Education, 2018c:7).

The SBA policy document for Grades 1 to 3 prescribes that learners complete activities that are practical, oral and written under specific CAPS topics, as seen in the example (Table 4-16) given above. Teachers are provided with checklists and rubrics to assess the learners' gestures and physical movement (see Tables 4-16, 4-17 and 4-18) (Department of Basic Education, 2018b:43, 45).

As seen in the discussion above, because of the integrated nature of the Life Skills subject, the assessment of learners' gestures and physical activities is prescribed in the policy documents for Grades R to 3. The documents prescribe using the context of a Science topic as the basis of Creative Arts and Physical Education activities. There is a noticeable difference between the occurrence of this type of assessment for Grade R and for Grades 1 to 3. The data from the participants from Farm and Township schools, however, confirm that the assessment of gestures or physical activity often takes place.

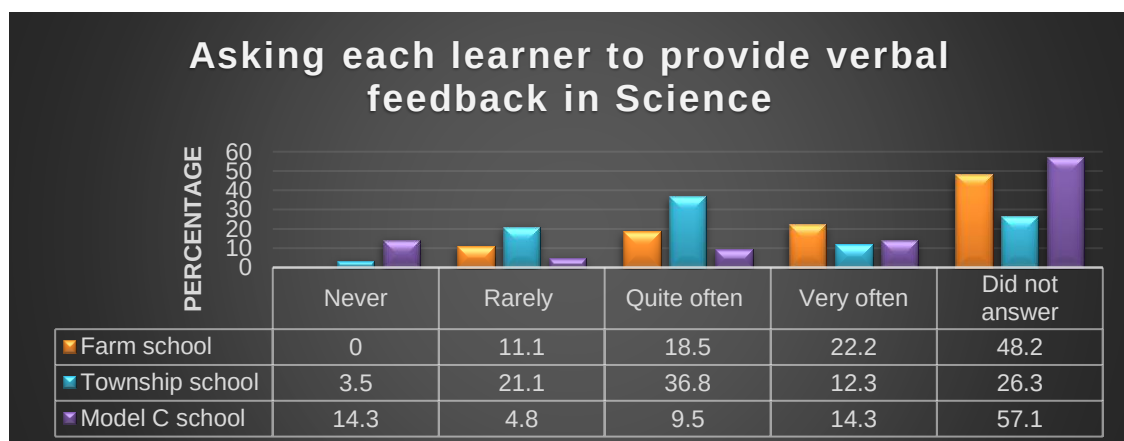


Figure 4-25: Asking learners to provide verbal feedback in Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that they often assessed learners' verbal feedback in Science (see Figure 4-25).

As mentioned in the discussion above, the policy documents prescribe using the context of a CAPS Science topic, such as weather, transport and animals, as the theme of Creative Arts and

Physical Education activities (Department of Basic Education, 2011a:8-9; 2021c:11-22). These activities include dramatising stories, making storyboards and saying different rhymes and songs (see Tables 4-13 and 4-16) (Department of Basic Education, 2018b:43; 2018c:7).

The SBA policy document provides assessment plans, rubrics and checklists (see Tables 4-13, 4-14 and 4-15) for observation-based assessment of Grade R learners' verbal feedback on their understanding of the Life Skills content (Department of Basic Education, 2018c:7). Observation of Grade R learners' verbal feedback is prescribed to be assessed within the daily programme (Department of Basic Education, 2011b:15).

According to the SBA policy document for Grades 1 to 3, it is prescribed that learners complete activities that are practical, oral and written under specific CAPS topics. In Life Skills, there are multiple prescribed assessments of verbal feedback. Teachers are provided with checklists and rubrics to assess the verbal feedback on learners' understanding and knowledge (see Tables 4-16, 4-17 and 4-18) (Department of Basic Education, 2018b:43, 45).

As is prescribed by the policy documents the assessment of learners' verbal feedback forms a major part of the Life Skills assessment plan for all learners in Grades R to 3. The integrated nature of the Life Skills content according to which teachers are prescribed to integrate a Science topic as the basis of Creative Arts and Physical Education activities has an impact on the occurrence of different types of assessment. The results from the data confirm that the assessment of verbal feedback often takes place.

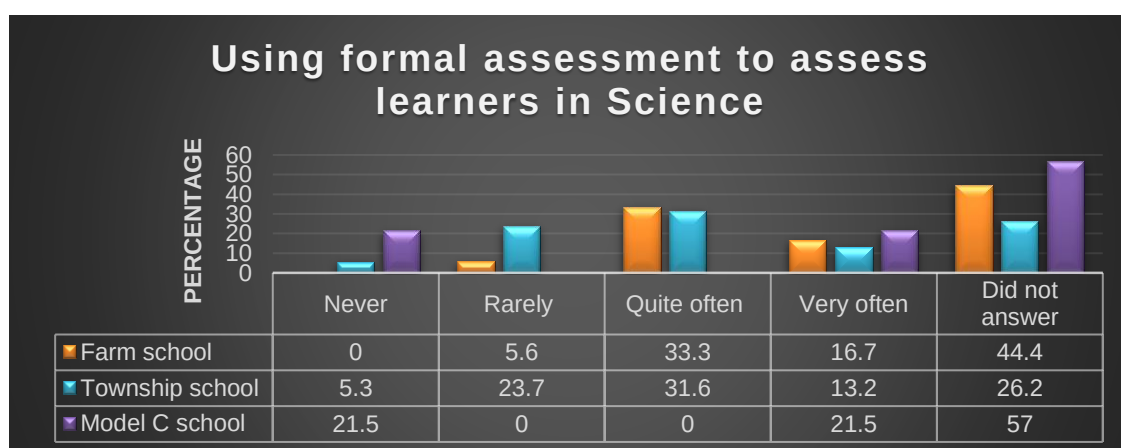


Figure 4-26: Using formal assessment in Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants reported that they often formally assessed learners in Science. Of the participants

from the Model C school, however, equal percentages indicated that they very often and never used formal assessment in Science teaching (see Figure 4-26).

Both the ATP and SBA policy documents for Life Skills (integrated subject containing Science content) provide teachers with general timelines for the assessment of learners (Department of Basic Education, 2018b:42; 2018c:7). Teachers are prescribed one of four types of formal assessment, namely observation, oral, practical or written (see Tables 4-13 and 4-16). The learners' results for these assessments are recorded and used for promoting them to the following Grade (Department of Basic Education, 2018b:42; 2018c:7).

The policy documents prescribe formal assessment as an ongoing daily, weekly or monthly activity or an activity per term in Life Skills (Department of Basic Education, 2018b:42; 2018c:7). Due to the integrated nature of Life Skills, where a Science topic is incorporated into all four of the learning areas (where possible), formal assessment often takes place.

4.5.4 Question 25 of the adapted Creative Little Scientists questionnaire

Question 25 was “**How often do you assess your learners in MATHEMATICS in the following ways?**”. See Table 4-19 below for a breakdown of the sub-questions and the Likert scale.

Table 4-19: Assessment in Mathematics

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Evaluating learners classroom artefacts which show their scientific reasoning				
b. Evaluating learners relevant gestures or physical activity				
c. Asking each Learner to provide verbal feedback				
d. Using formal assessment				

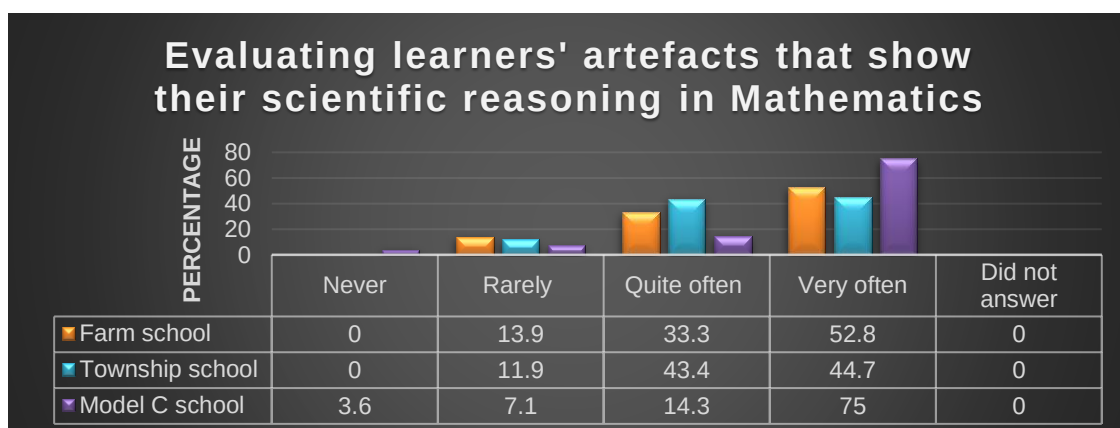


Figure 4-27: Evaluating learners' artefacts in Mathematics

The participants reported that they often assessed learners' artefacts as a measurement of scientific reasoning in Mathematics (see Figure 4-27).

The ATP policy document for Mathematics provides teachers with a general indication of the assessment that needs to take place under a CAPS topic (Department of Basic Education, 2021a:1-3). The document refers to prerequisite knowledge assessment as well as formal and informal assessment. Teachers are referred to the SBA policy document (Department of Basic Education, 2021a:1-3) for details on assessments.

Grade R learners, according to the ATP policy document, are only assessed based on observations done by the teacher of their oral and practical work (Department of Basic Education, 2021e:1-3). As seen in Table 4-20 below, which is extracted from the SBA policy document, teachers observe learners' interaction with manipulatives and classroom material instead of artefacts in a written or visual form.

Table 4-20: Extracted example of SBA assessment plan for Grade R Mathematics (Department of Basic Education, 2018c:6)

Term 1: Mathematics Grade R							
Activities	Skills for informal assessment	Forms of assessment	Assessment tool	Assessment method	Score	Date to be completed	Date completed
1	Estimate and rote counts up to 5	Observation	Rubric 1	Oral / Practical	3	On or before the end of the term	
2	Copies, extends and creates own pattern		Rubric 2	Practical	3		

Term 1: Mathematics Grade R							
Activi- ties	Skills for informal assessment	Forms of assessment	Assessment tool	Assessment method	Score	Date to be completed	Date completed
3	- Knows the number symbol and number name 1 - Identifies pictures and dot card that involves number 1		Rubric 3	Oral / Practical	3		
4	Recognises, identifies 3 D objects example balls, boxes		Checklist	Practical	n/a		
5	- Knows on, in, up, down - Understands backwards, forward, front, back		Checklist	Oral / Practical	n/a		
6	- Describes, sort and compares 3D objects and according to shape - Able to collect and sort draw, read represent object according to one attribute		Checklist	Practical	n/a		
7	Order recurring events in own daily life (examples daily programme) (ongoing)		Rubric 4	Oral / Practical	3		
Teacher notes: The above skills will be observed during the integrated daily programme. Many skills are integrated in Home Language, Mathematics and Life Skills and cannot be separated in Grade R. All skills listed are not meant to be an assessment activity but rather you ensure that your learners are afforded many opportunities to learn and practice the skills demonstrated in many ways. The skills listed below are taught but do not appear on the checklist or rubric. - Uses language to give explanations - Develops language to develop concepts for shapes, colour and age - Builds at least a 6 piece puzzle - Shows ability to distinguish between objects in foreground/background - Distinguish between tall, taller, tallest, short, shorter, shortest (height chart) - Compares which of the two given collection of objects are bigger, smaller, biggest and smallest - Short objects according to: size - big and small, objects that roll and slide - Recognises line of symmetry in self - Identifies patterns in the environment - Counting rhymes and games - Understands ordinal numbers - Understands one to one correspondence - Uses concrete apparatus to solve problems - Identifies and recognizes circle, triangle and square - Understands words example: day, night, light and dark, morning, afternoon, tonight to describe time of day - Shows awareness of days of the week, seasons end weather - Knows own birthdate - Recognises, identifies and names his or her own symbol, his or her peers symbol end class name By the end of the term (or week 9) you should be able to complete the checklist and score each learner according to the rubric.							

Table 4-21: Extracted example of SBA rubric for Grade R Mathematics (Department of Basic Education, 2018c:6)

Mathematics: Rubric 1: Estimates and rote counts up to 5

3	Easily estimates and counts orally up to 5.
2	Starts to estimate and counts orally up to 5.
1	Still very unsure how to estimate and counts orally up to 5.

Mathematics: Rubric 2: Copies, extends and creates own patterns

3	Easily copies, extends and creates own patterns as he/she understand the concept.
2	Is able to understand, therefore is starting to try to copy or create his / her own patterns.
1	Still very unsure and has not mastered the skill to copy, extend and creates own patterns.

Mathematics: Rubric 3: Knows the number symbol 1 and recognises the number name (one) & identifies number pictures and dot cards of 1 e.g. 1

3	Easily identifies number symbol 1, name and picture with dot.
2	Is able to understand the concept and identifies number symbol 1, name and picture with dot.
1	Still very unsure and struggles to identifies number symbol 1, name and picture with dot.

Unlike the Grade R assessment, the SBA policy document provides teachers teaching Grades 1 to 3 with a timeline and guidelines of what artefacts need to be assessed throughout the year (Department of Basic Education, 2018a:51-52). As seen in the example below (Table 4-22), teachers are required to assess multiple artefacts throughout the term using the checklists (see Table 4-23) or rubrics (see Table 4-24) provided.

Table 4-22: Extracted example of SBA assessment plan for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:51-52)

Mathematics- Programme of assessment: Grade 3 Term 1						
Content area	Skills for informal assessment	Forms of assessment	Assessment tool	Score	Date to be completed	Date completed
Numbers, Operations and Relationships	Counting: Group to at least 200 objects to estimate and count reliably. Count forwards and backwards in: • 1s from any number between 0 and 200 • 10s from any multiple of 10 between 0 and 200 • 5s from any multiple of 5 between 0 and 200 • 2s from any multiple of 2 between 0 and 200 • 3s from any multiple of 3 between 0 and 200 • 4s from any multiple of 4 between 0 and 200 • 100s to at least 500 • Identify, recognise and read number symbols up to 500	Oral	Checklist	n/a	By end of the term	

Mathematics- Programme of assessment: Grade 3 Term 1						
Content area	Skills for informal assessment	Forms of assessment	Assessment tool	Score	Date to be completed	Date completed
	Mental Mathematics: Rapidly recall - Recall addition and subtraction facts to 20 - Compare numbers to 200 and say which is 1/2/3/4/5/10 more/less					
	Add or subtract multiples of 10 from 0 to 100		Rubric	5		
	Number symbols and number names - Write number symbols 0 to 500 - Identify, recognise and reads number names 0 to 250 - Write number names 0 to 100		Class workbook/ worksheet	10	By week 8	
	Describe, compare and order numbers up to 99 - Compare whole numbers and order whole numbers up to 99 - Position objects in a line from first to twentieth or first to last					
	Recognise place value of numbers 11 to 99 - Know what each digit represents - Decompose two-digit numbers into multiple of tens and ones/units - Identify and state the value of each digit	Oral and practical	Checklist	n/a	By end of the term	
	Context-free calculations - Add to 99, Subtract from 99 - Multiply numbers 1 to 10 by 2, 5 and 3, 4 - Divide numbers to 50 by 2, 5, 10 Money - Recognise and identify the South African coins 10c, 20c, 50c, R1, R2, R5, and bank notes R10, R20, R50	Written	Class workbook/ worksheet	10	By week 8	
	Fractions: Solve word problems in context and explain own solutions to problems that involve equal sharing leading to solutions that include unitary fractions	Written	Class workbook/ worksheet	5	By week 8	
	Solve word problems in context:	Written	Class workbook/ worksheet	10	By week 8	

Mathematics- Programme of assessment: Grade 3 Term 1						
Content area	Skills for informal assessment	Forms of assessment	Assessment tool	Score	Date to be completed	Date completed
	- Explain own solution to problems involving addition and subtraction with answers up to 99 - Solve word problems in context and explain own solution to problems involving repeated addition and to multiplication with answers up to 50 - Solve word problems in context and explain own solutions to problems that involve equal sharing and grouping up to 50 with answers that may include remainders					
Patterns, Functions & Algebra	Number patterns: Copy, extend and describe simple number sequences to at least 200 counting forwards and backwards in: 3s from any multiple of 3 between 0 and 200 4s from any multiple of 4 between 0 and 200 100s from any multiple of 100 to 500	Written	Class workbook/ worksheet	5	By end of the term	
Shape & Space	2-D-shapes: Range of shapes: Recognise and name 2-D shapes circles, triangles, squares, rectangle	Written	Class workbook/ worksheet	5	By end of the term	
Measure-ment	Time - Read dates on calendars - Place birthdays, religious festivals, public holidays, historical events, school events on a calendar	Oral and practical	Rubric	5	By end of the term	
	Tell 12-hour time in hours, half hours and quarter hours and minutes	Written	Class workbook/ worksheet	5		
	Capacity Compare, order and record the capacity of commercially packaged objects whose capacity is stated in litres					
	- Know that a standard cup is 250 millilitres - Know that a teaspoon is 5 millilitres	Oral and practical	Checklist	n/a		

Mathematics- Programme of assessment: Grade 3 Term 1						
Content area	Skills for informal assessment	Forms of assessment	Assessment tool	Score	Date to be completed	Date completed
Data handling	Represent data in: - Tables/ - Bar graphs	Written	Class work book/ worksheet	5	By end of the term	
Teacher note: Written examples should include at least 2 examples for each skill/concept and should be done in a worksheet format. The written activities for Numbers, Operations and Relationships and Patterns should be done in 1 worksheet and the duration should be 30-40 minutes. The written activities for Shape and Space, Measurement and Data Handling should be done in another worksheet and the duration should be 15-20 minutes. These written assessments should be done in small groups and should include easy items (50%) and moderate items (50%). For Word Problems, refer to the problem types in CAPS pages 79 -81						
Total score 65						
Scores will be captured on SASAMS. The score will be converted to a percentage to indicate level 1-7 for the report card.						

Table 4-23: Extracted example of SBA checklist for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:53)

Mathematics: GRADE 3: TERM 1: Checklist															
✓ - achieved ✗ - not yet • - almost	Date	Numbers, Operations & Relationships										Measurement	Comments		
		Counting: Group to at least 200 objects to estimate and count reliably.	Count forwards and backwards in: 1s from any number between 0 and 200	10s from any multiple of 10 between 0 and 200	5s from any multiple of 5 between 0 and 200	2s from any multiple of 2 between 0 and 200	3s from any multiple of 3 between 0 and 200	4s from any multiple of 4 between 0 and 200	100s to at least 500	Identify, recognise and read number symbols up to 500.	Mental Mathematics: Rapidly recall Recall addition and subtraction facts to 20	Mental Mathematics: Rapidly recall Compare numbers to 200 and say which is greater/smaller.	Recognise place value of numbers 11 to 99 Know what each digit represents Decompose two-digit numbers into multiple of tens and ones/units Identify and state the value of each digit	Capacity Know that a standard cup is 250 millilitres Know that a teaspoon is 5 millilitres	
Names of learners															
1															
2															

Table 4-24: Extracted example of SBA rubric for Grades 1 to 3 Mathematics (Department of Basic Education, 2018a:55)

Mathematics: Grade 3 :Term 1 Suggested Rubrics					
Numbers, Operations & Relationships					
Activity (oral)	1	2	3	4	5
Add or subtract multiples of 10 from 0 to 100	Is able to add multiples of 10 from 0 to 20-30 with support	Is able to add multiples of 10 from 0 to 40-50 correctly	Is able to add and subtract multiples of 60-70 correctly	Is able to add and subtract multiples of 10 from 0 to 80-90 with speed and accuracy	Is able to add and subtract multiples of 10 from 0 to 100 with speed and accuracy
Measurement					
Activity (practical)	1	2	3	4	5
Read dates on calendars, place birthdays, religious festivals, public holidays, historical events, school events on a calendar	Is still learning to read dates from the calendar,	Is able to read dates and place birthdays, on a calendar with support	Is able to read dates, place birthdays, school events on a calendar correctly	Is able to read dates, place birthdays, public holidays, school events on a calendar correctly	Is able to read dates, place birthdays, religious festivals, public holidays, historical events, school events on a calendar correctly

Although teachers from different types of schools often assess learner artefacts, the type of assessment used for Grade R differs from the assessment in Grades 1 to 3 in South Africa. The occurrence of assessing artefacts is stipulated in both the ATP and the SBA policy documents.

The Grade R curriculum is designed as play-based activities where learners are assessed with the use of practical and oral activities and little focus on activities based on problem solving. In Grades 1 to 3, learners are assessed specifically on artefacts where they show problem-solving skills such as those seen under fractions and solving word problems in Table 4-22 above.

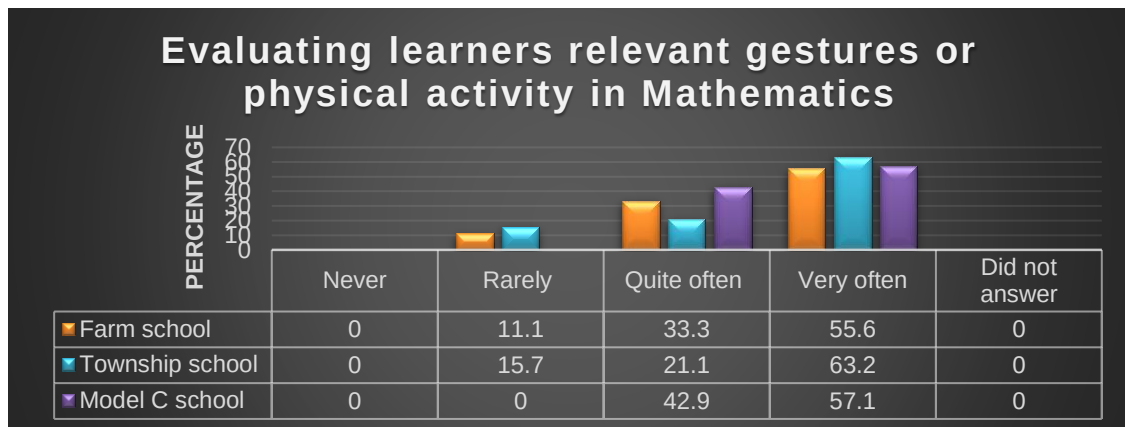


Figure 4-28: Evaluating learners' gestures or physical activity in Mathematics

The participants reported that they often assessed learners' gestures or physical activity in Mathematics (see Figure 4-28).

As mentioned above (see Section 4.5.3), the Grade R curriculum is structured as play-based activities, and learners are only assessed by the teachers' observations of them (Department of Basic Education, 2018c:6). Learners are observed when they, for example, build puzzles or participate in counting rhymes and games. The results from the observations of learners' oral and practical work are recorded and used to promote learners to the next grade. These observations are indicated in the SBA document as a daily activity (Department of Basic Education, 2018c:6).

According to the SBA for Grades 1 to 3, learners in these grades are assessed less on practical and oral activities, and with a stronger focus on written work. Practical activities are prescribed in the content area (CAPS topic) of shape and space, where learners are required to sort objects and measurement and have to compare the weight and length of objects (Department of Basic Education, 2018a:22).

As seen in the above discussion, the assessment of learners' gestures and physical activities is prescribed in the policy documents, with guidelines on how often such assessment should take place. There is a noticeable difference in the occurrence of this type of assessment for Grade R

learners and learners in Grades 1, 2 and 3. The data from the participants, however, confirm that the assessment of gestures or physical activity often takes place in Grades R to 3.

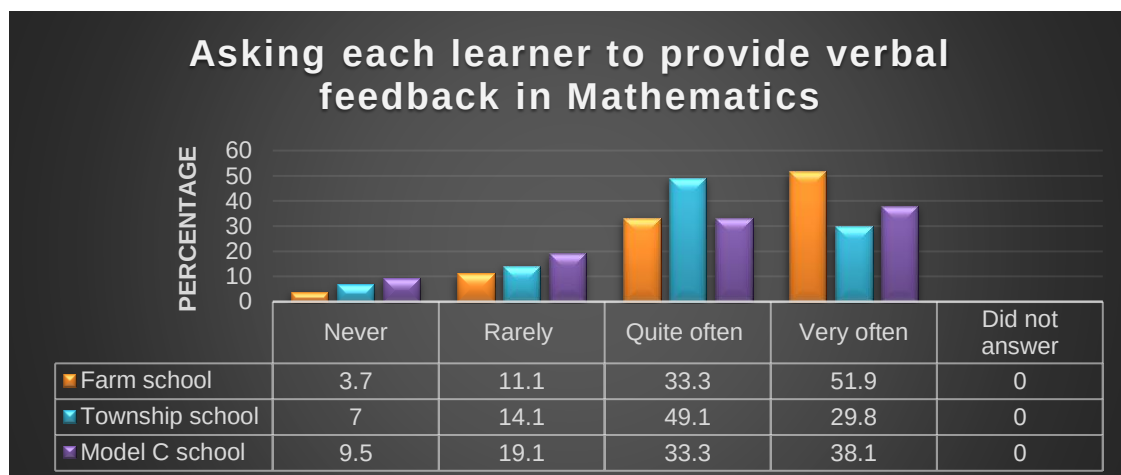


Figure 4-29: Asking learners' verbal feedback in Mathematics

The participants reported that they often made use of verbal feedback as part of assessing learners in Mathematics (see Figure 4-29).

The overall focus of the assessment in Grade R is based on observing verbal feedback on the learners' understanding (see Table 4-20). The observation of Grade R learners' verbal feedback is prescribed to be assessed within the daily programme (Department of Basic Education, 2011b:15).

As mentioned in the previous discussion above, the focus of the assessment of learners in Grades 1 to 3 is on written work. There are, however, activities where learners are assessed based on their verbal feedback. These activities are prescribed in the content area (CAPS topic) of numbers, operations and relationships, where learners are required to count or recall verbally, and in the content area of measurement, where learners are required to read dates and tell time (see Tables 4-23 and 4-24) (Department of Basic Education, 2018a:22).

There is a noticeable difference in the occurrence of assessing learners' verbal feedback in Mathematics in Grade R versus Grades 1, 2 and 3, as can be seen in the policy documents. The results from the data confirm that the assessment of verbal feedback often takes place in Grade R to 3 (Foundation Phase).

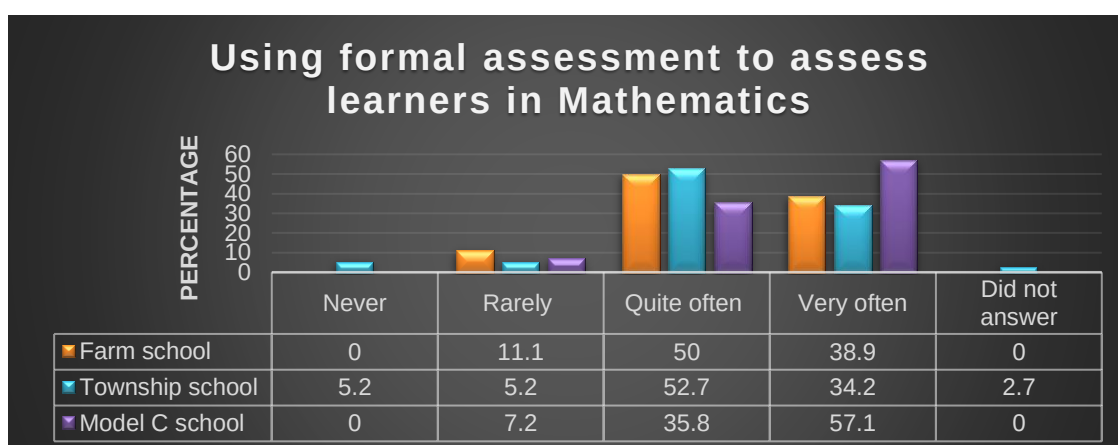


Figure 4-30: Using formal assessment in Mathematics

Of the participating teachers, 0.9% opted not to answer the question. The remaining participants reported that they often used formal assessment in Mathematics (see Figure 4-30).

Both the ATP and the SBA policy documents provide teachers with general timelines for the assessment of learners. Teachers are prescribed one of three types of formal assessment, namely oral, practical or written (see Tables 4-20 and 4-23). The learners' results in these assessments are recorded and used for promoting them to the following Grade (Department of Basic Education, 2018a:51-52; 2018c:6).

The policy documents prescribe formal assessment as an ongoing daily, weekly, monthly or per-term activity in Mathematics. This is supported by the results from the participating teachers that indicated that they often perform this activity.

4.5.5 Question 26 of the adapted Creative Little Scientists questionnaire

Question 26 was “**How often do you reward/praise the following characteristic in your learners in SCIENCE?**”. See Table 4-25 below for a breakdown of the Likert scale.

Table 4-25: Using reward/praise in Science

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Innovation, creativity and problem solving				

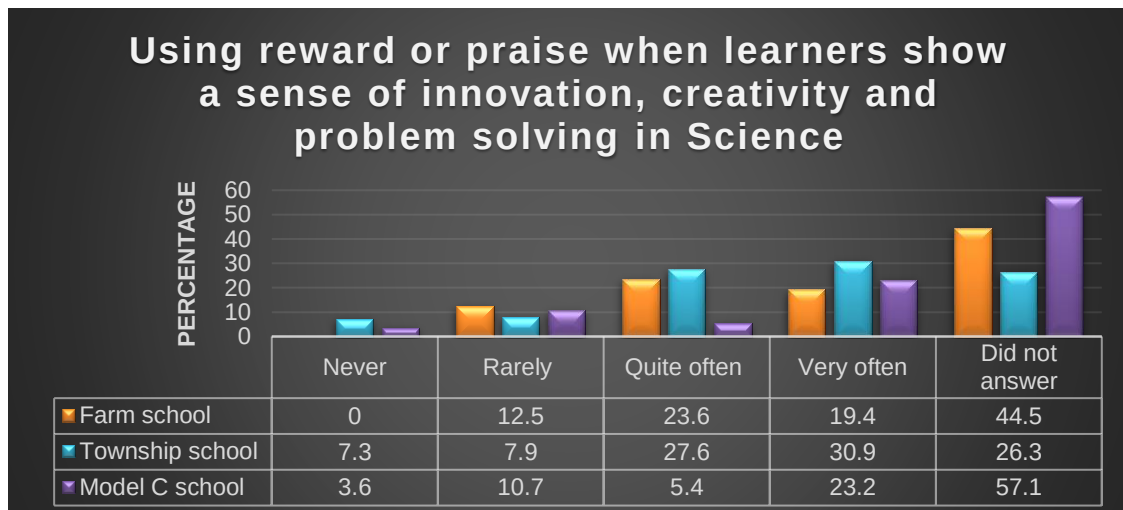


Figure 4-31: Using reward or praise for innovation and creativity in Science

A total of 42.6% of the participating teachers opted not to answer the question regarding the rewarding or praising of learners in Science. The remaining participants indicated that they often rewarded or praised learners for innovation and creativity in solving Science-based problems (see Figure 4-31).

Although using rewards or praise is not indicated in the ATP document, the perception of the teachers is that they often need to reward or praise learners for innovation and creativity in the teaching and learning activities of Science. This is important in fostering a positive attitude towards Science learning.

4.5.6 Question 27 of the adapted Creative Little Scientists questionnaire

Question 27 was “**How often do you reward/praise the following characteristics in your learners in MATHEMATICS?**”. See Table 4-26 below for a breakdown of the Likert scale.

Table 4-26: Using reward or praise in Mathematics

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Innovation, creativity and problem solving				

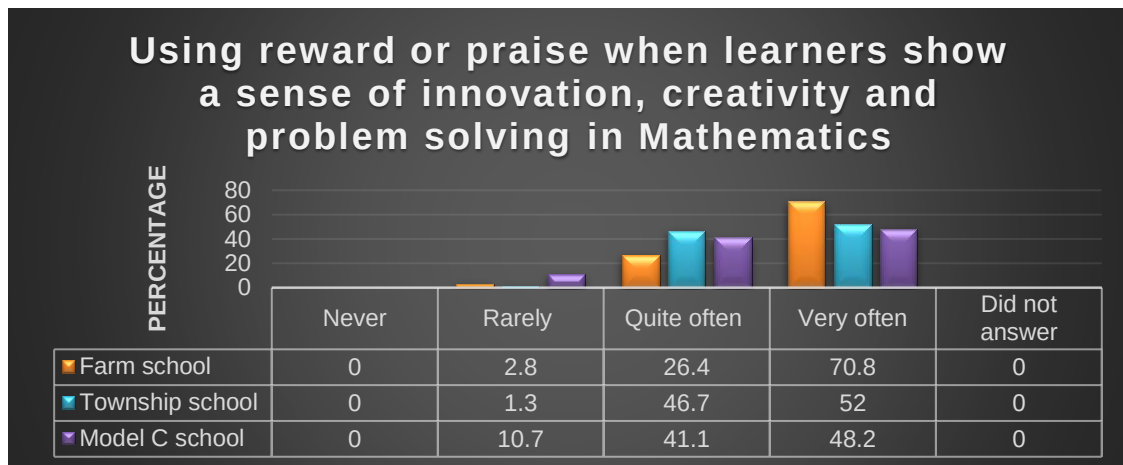


Figure 4-32: Using reward or praise for innovation and creativity in Mathematics

The majority of the participants reported that they often rewarded or praised learners for innovation and creativity in solving Mathematic problems. The participants from Farm schools indicated that they rewarded and praised learners for innovation and creativity more often than the participants from the other types of schools (see Figure 4-32).

The main focus in Mathematics is on the development of the core concepts of Mathematics instead of developing learners' personal skills and values (Department of Basic Education, 2021a:1-2). As the focus is on the development of core concepts, it is important that teachers reward and praise learners for innovation and creativity in order to foster a positive attitude towards Mathematics learning.

4.5.7 Question 28 of the adapted Creative Little Scientists questionnaire

Question 28 was "How often do you use **ASSESSMENTS** of learners in **SCIENCE** for the following purposes?". See Table 4-27 below for a breakdown of the Likert scale.

Table 4-27: Using assessment in Science to inform teaching and learning activities

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To inform of areas for improvement in the Science teaching and learning activities				

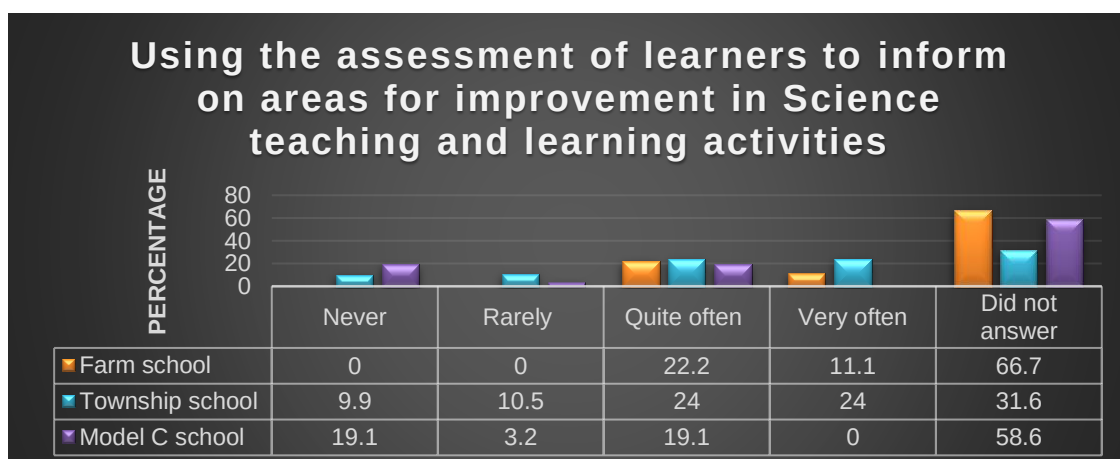


Figure 4-33: Using the assessment of learners to inform teaching and learning activities in Science

A total of 52.3% of the participating teachers opted not to answer the question. The remaining participants reported that they often assessed learners to inform teaching and learning activities in Science. Equal numbers of the participants from the Model C school indicated that they quite often or (in contradiction with this) never assess learners (see Figure 4-33).

The ATP for Life Skills (integrated subject containing Science content) prescribes that weekly or daily informal assessment of learners' skills, knowledge application, attitude and values is needed to inform teachers on areas for improvement (Department of Basic Education, 2021c:11-22). As this activity forms part of the ATP for Life Skills and the prescribed assessment under each CAPS topic, teachers should often assess learners to inform their teaching and learning activities in Science.

4.5.8 Question 29 of the adapted Creative Little Scientists questionnaire

Question 29 was "How often do you use ASSESSMENTS of learners in MATHEMATICS for the following purposes?". See Table 4-28 below for a breakdown of the Likert scale.

Table 4-28: Using assessment in Mathematics to inform teaching and learning activities

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To inform of areas for improvement in the Mathematics teaching and learning activities				

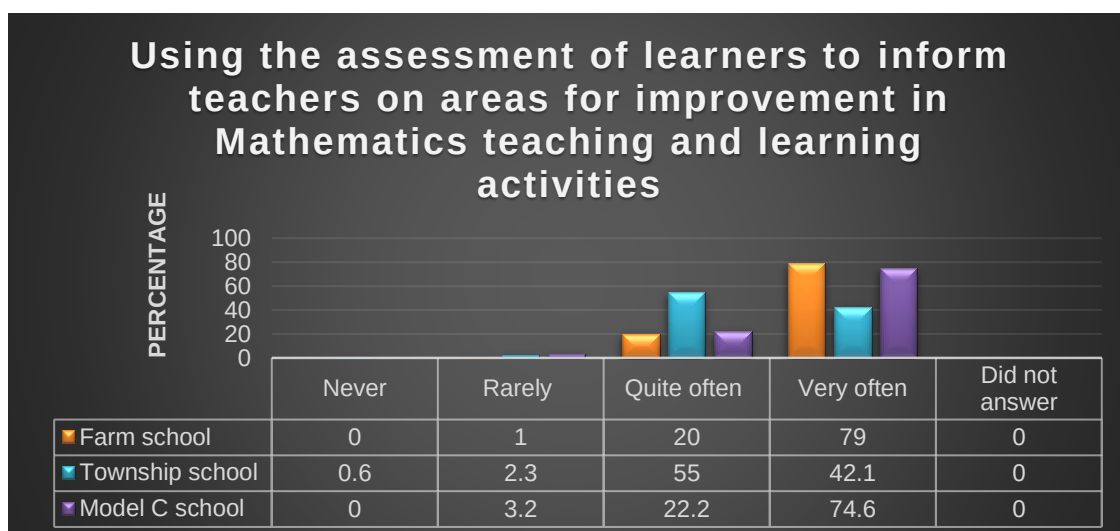


Figure 4-34: Using the assessment of learners to inform teaching and learning activities in Mathematics

The participants reported that they often assessed learners to inform them on areas for improving teaching and learning activities in Mathematics. The participants from the Township schools indicated that they used the assessment of learners to inform teaching and learning activities in Mathematics less often than the participants from the other two types of schools (see Figure 4-34).

The ATP for Mathematics prescribes that weekly informal assessment of learners' knowledge of core concepts, skills and values is needed to inform areas for improvement (Department of Basic Education, 2021a:3). In line with this, the teachers' perception is that it is important to assess learners to inform the teaching and learning activities in Mathematics. The teachers' perception of how often this assessment should take place differs between the different types of schools.

4.5.9 Summary of the pedagogical phenomenon of assessment

A summary of the results that emanated from Questions 22, 23, 24, 25, 26, 27, 28 and 29 includes the teachers' views on the assessment of learners in Science and Mathematics. Furthermore, the discussions of the various questions indicated what the policy documents prescribe with regard to assessment and the teachers' interpretation thereof.

The overall view of the participating teachers from all three types of schools is that it is important to assess learners in both Science and Mathematics. The teachers often assess learners' knowledge of scientific ideas, understanding of processes, attitudes, innovation and creativity in

order to inform teaching and learning activities in both Science and Mathematics. The teachers also often use formal assessment, including the assessment of artefacts, relevant gestures or physical activity and verbal feedback.

Policy documents tend to focus on the assessment of knowledge rather than skills and values in the learners' artefacts, relevant gestures or physical activity and verbal feedback in both Science and Mathematics. As the subject of Life Skills is an integrated subject with four learning areas (Beginning Knowledge, Creative Arts, Physical Education and Personal and Social Well-being), the policy documents frequently focus on assessment activities that use artefacts, relevant gestures or physical activity and verbal feedback (Department of Basic Education, 2018b:43, 45). This type of assessment should be done daily as the only form of assessment for Grade R learners (Department of Basic Education, 2018c:7). Although the CAPS and ATP policy documents for Life Skills list skills and values that learners must attain when completing teaching and learning activities under specific CAPS topics, these skills and values are not assessed formally by using checklists and rubrics (Department of Basic Education, 2018b:42, 43, 45; 2018c:7, 9, 11).

The Grade R assessment plan (SBA) for Mathematics includes the informal assessment of learners' skills and values along with their knowledge of Mathematics concepts (Department of Basic Education, 2018c:6). Grade R learners do not complete any written work and are assessed based purely on the observation of their artefacts, relevant gestures or physical activity and verbal feedback on almost a daily basis (Department of Basic Education, 2018c:6). The policy documents for learners in Grades 1 to 3 primarily focus on the attainment and assessment of core concepts and knowledge rather than skills and values (Department of Basic Education, 2021a:1-3). The assessment of these learners is focused more on written work and less on oral or practical activities. When compared to the assessment of Life Skills, it is seen that in Life Skills, teachers make use of artefacts, relevant gestures, physical activity and verbal feedback as assessment tools more often than in assessment for Mathematics (Grades 1 to 3) (Department of Basic Education, 2018a:51-52).

From the above, it is seen that there is a difference between the methods and content of assessment in Life Skills and Mathematics. There is also a noticeable difference between the assessment of Grade R learners and learners in Grades 1 to 3. The main focus of assessment in Life Skills Grades 1 to 3 is on learners' knowledge and multiple activities through the assessment of artefacts, relevant gestures or physical activity and verbal feedback. In contrast to this, the assessment of Mathematics Grades 1 to 3 focuses more on the assessment of core concepts and knowledge in written form. Grade R learners are assessed based only on observations in

both Life Skills and Mathematics, with a focus on providing learners with the opportunity to practise skills.

4.6 Pedagogical phenomenon: instructional method

The following questions from the adapted Creative Little Scientists questionnaire provided data supporting the pedagogical phenomenon of instructional method in South Africa: Questions 15 (how often the teacher uses specific learning and teaching contexts and approaches when teaching Science), 16 (how often the teacher uses specific learning and teaching contexts and approaches when teaching Mathematics), 17 (how often the teacher encourages activities such as observing, design and construction in Science), 18 (how often the teacher encourages activities such as observing, design and construction in Mathematics), 19 (what approach – open, guided or structured – the teacher follows in the Science classroom), 20 (what approach – open, guided or structured – the teacher follows in the Mathematics classroom) and 21 (the teacher’s view on the role of the teacher in fostering inquiry skills).

4.6.1 Question 15 of the adapted Creative Little Scientists questionnaire

Question 15 was “**How often do you use the following learning/teaching contexts and approaches in your SCIENCE teaching?**”. See Table 4-29 below for a breakdown of the sub-questions and the Likert scale.

Table 4-29: Context and approaches in Science

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Approaches (example, open / unstructured play, working in small groups or outdoor learning activities)				
b. Context (example, teaching from stories, using history or field trips)				

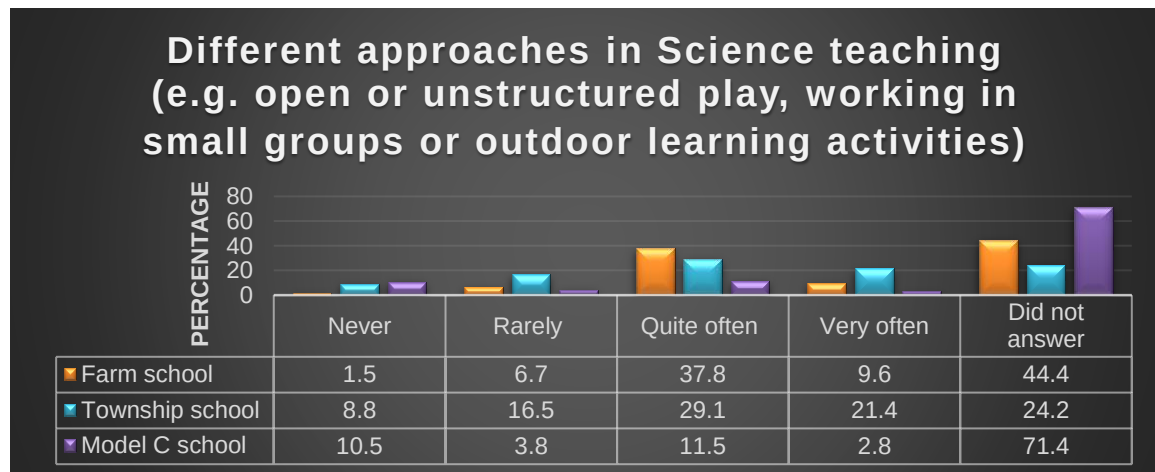


Figure 4-35: Using different approaches in Science teaching

A total of 46.7% of the participating teachers opted not to answer the question. The remaining participants reported that they often made use of different approaches in their Science teaching (see Figure 4-35). It is important to note that the Covid-19 pandemic rules and regulations (2020 to February 2022), in effect during the time period that data was gathered, prescribed that learners must maintain a distance of at least one meter from one another and prohibited the sharing of equipment and material. These rules could have had an impact on the results by changing the approaches that the teachers might have preferred to use.

The CAPS policy document for Life Skills (integrated subject containing Science content) suggests that the timetable for Grade R to 3 (Foundation Phase) should consist of routine activities, free-play activities indoors and outdoors and structured activities (Department of Basic Education, 2011a:10). The focus of the free-play activities should be the content of the Physical Education and Creative Arts learning areas (Department of Basic Education, 2011a:10). Furthermore, the document suggests that especially Grade R learners should have access to a play environment, including a space with blankets, cushions and a workspace with tables and chairs (not desks) (Department of Basic Education, 2011a:10). The CAPS policy document suggests activities for free play inside and outside (Department of Basic Education, 2011a:11). Examples provided for free play inside are “free art, tearing, cutting, pasting, block area, fine motor activities, sand box, fantasy play, book area, discovery area, music area, writing area and block play” (Department of Basic Education, 2011a:11). Examples provided for free play outside are “water (and mud) play, sand play, sensory play, fantasy play, gross motor play, block play, ball play, wheel toys, construction, gardening, caring for animals and outside art activities” (Department of Basic Education, 2011a:11). There is no indication of working in small groups in the CAPS policy document for Life Skills.

The ATP document encourages play as an important pedagogy for all learners in Grades R to 3 in Life Skills and states that it is important for learners to be a part of a group (Department of Basic Education, 2021c:11-22). The document does not provide teachers with an indication of when different approaches (unstructured play, working in small groups or outdoor learning) must take place.

With regard to toys available in the participating schools, 9% of the participants from the Farm schools, 36.8% of the participants from Township schools and 80% of participants from the Model C school have toys available in the classroom for open and unstructured play. The classroom design is divided between classical and group arrangements (see Figures 4-36 and 4-37). Of the observed cases of Grade R to 3 classrooms, 72.7% of the participating classrooms from Farm schools, 63.2% of the participating classrooms from Township schools and 80% of the participating classrooms from Model C school, desks are placed in a classical arrangement – learners seated at a single desk or in pairs where the desk permits (see Figure 4-36 below for a classroom map of a classical arrangement). Of the observed cases, in 27.3% of the participating classrooms from Farm schools, 36.8% of the participating classrooms from Township schools and in 20% of the participating classrooms from the Model C school, desks were placed in a small-group arrangement (see Figure 4-37 below for a classroom map of a small-group arrangement). Furthermore, 33.3% of the participating Farm schools, 50% of the Township schools and the Model C school (i.e. 100%) had some form of outdoor play area for learners.

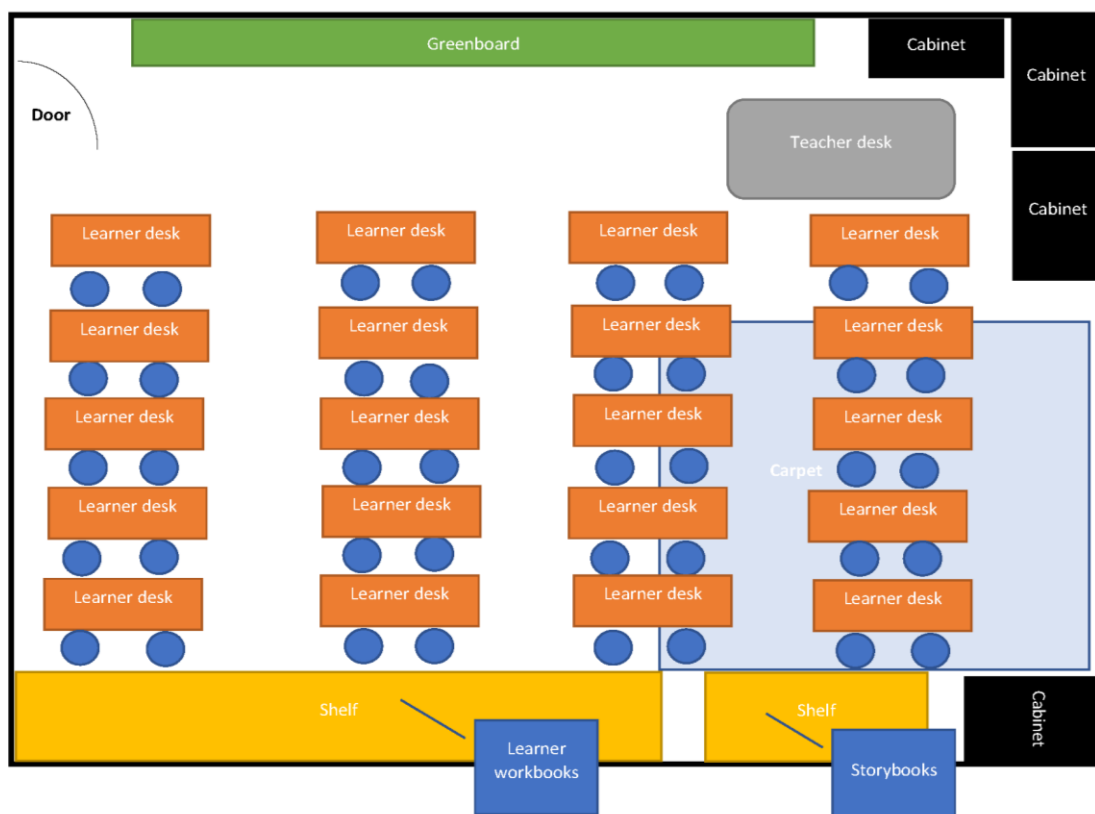


Figure 4-36: Map of classical classroom arrangement

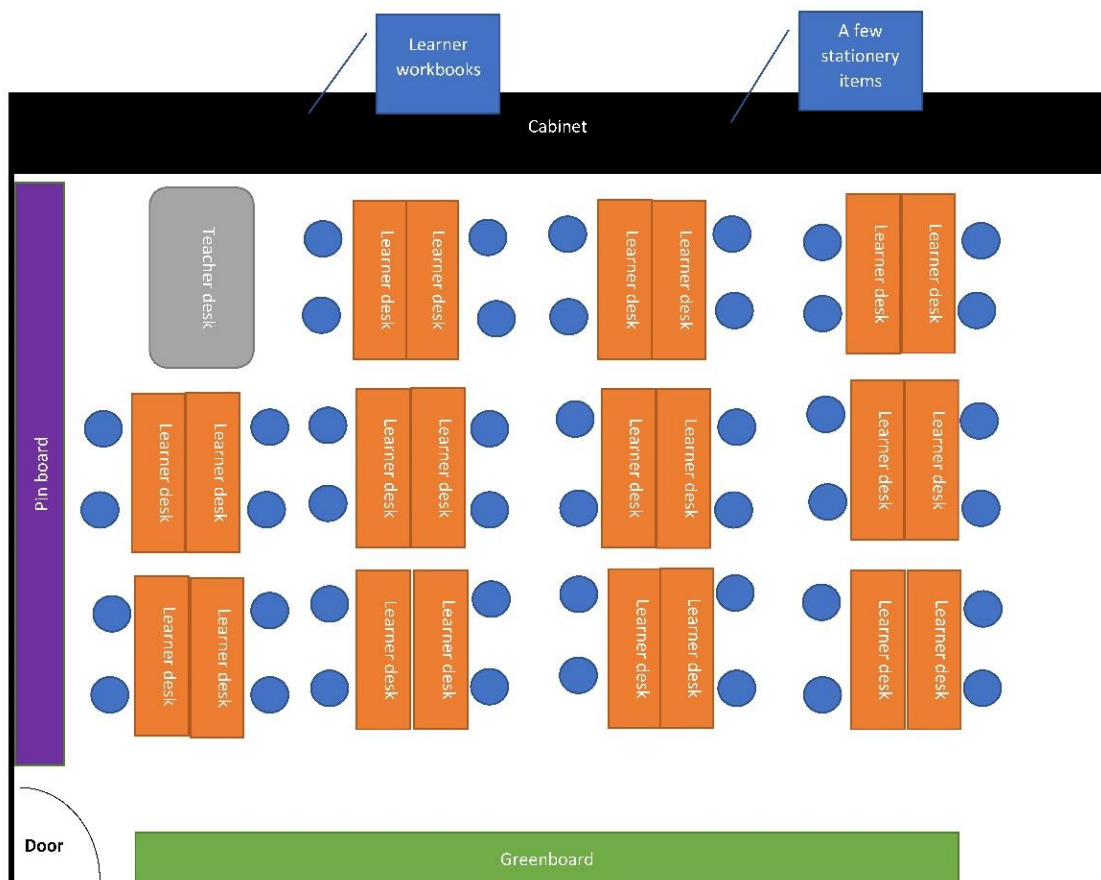


Figure 4-37: Map of grouped classroom arrangement

Although the policy documents provides some guidelines on the types of approaches that teachers can follow in teaching Life Skills, the policy leaves the choice of approach open for each individual teacher. The participating teachers indicated that they held the perception that it was important to often make use of different approaches when teaching Science. From the researcher's observations of the classroom arrangement, the majority of classrooms are not arranged in a manner that allows for the facilitation of group work. Due to restrictions set by the Department of Basic Education during the Covid-19 pandemic, the observed classroom arrangement may differ from what the participants prefer. The participating teachers indicated that they often made use of free-play activities inside and outside of the classroom. However, based on observations of the participating schools, the Farm and Township schools are not well equipped for inside and outside free-play activities.

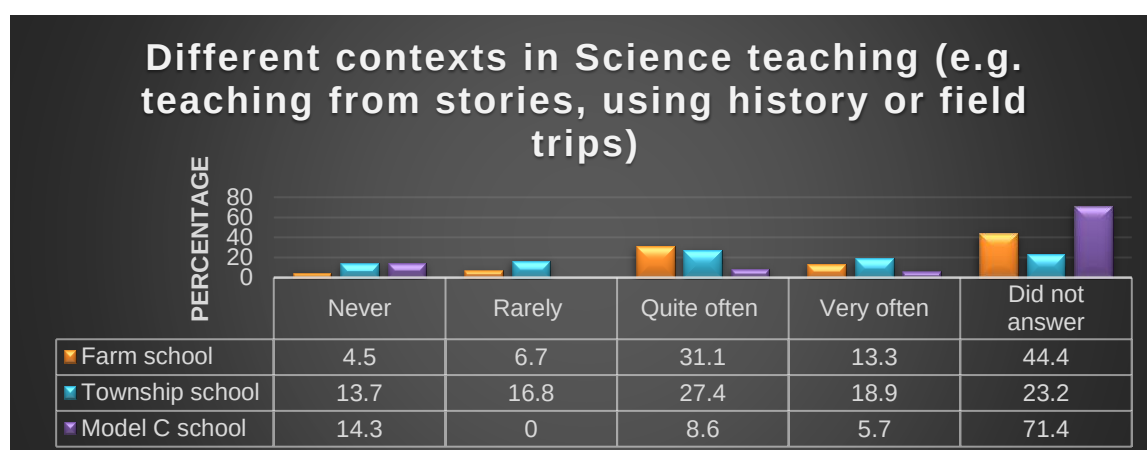


Figure 4-38: Using different contexts in Science teaching

Of the participating teachers, 46.3% opted not to answer the question. The remainder of the participants from the Farm and Township schools indicated that they often made use of stories, history or field trips as context when teaching Science. The participants from the Model C school indicated the same percentage for both never and quite or very often participating classrooms from participating classrooms from (see Figure 4-38). It is important to note that due to the Covid-19 pandemic rules and regulations (2020 to February 2022), the use of some approaches was prohibited, and this may have influenced the results.

As mentioned before, the subject of Life Skills (integrated subject containing Science content) consists of four learning areas, namely Beginning Knowledge, Personal and Social Well-being, Creative Arts and Physical Education. The integrated nature of Life Skills involves a CAPS topic being used as the context for teaching skills in all four learning areas (Department of Basic Education, 2021c:11-22). Although there is no specific reference in the CAPS policy document to making use of stories, history or field trips as context when teaching Life Skills, each CAPS topic provides teachers with a context for teaching and learning activities throughout the year (Department of Basic Education, 2011a).

As seen in the policy documents, teachers are to use a CAPS topic that indicates the context for teaching and learning activities in all four learning areas of Life Skills. Teachers are, however, not prescribed how to teach each CAPS topic. Therefore, they often make use of different stories, history and activities outside of the classroom to create a context for learners when teaching specific content.

4.6.2 Question 16 of the adapted Creative Little Scientists questionnaire

Question 16 was “How often do you use the following learning/teaching contexts and approaches in your MATHEMATICS teaching?”. See Table 4-30 below for a breakdown of the sub-questions and the Likert scale.

Table 4-30: Context and approaches in Mathematics

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Approaches (example, open / unstructured play, working in small groups or outdoor learning activities)				
b. Context (example, teaching from stories, using history or field trips)				

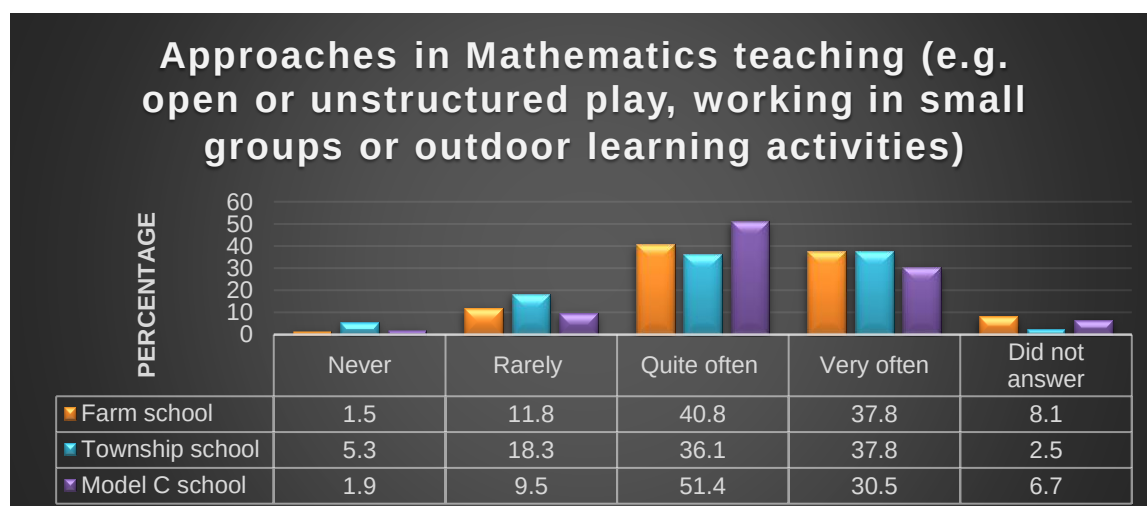


Figure 4-39: Using different approaches in Mathematics teaching

Of the participating teachers, 5.8% opted not to answer the question. The remaining participants indicated that they often made use of different approaches in teaching Mathematics (see Figure 4-39).

The CAPS policy document provides teachers with guidelines on what content is best taught with a specific approach. This document indicates the use of whole-class, small-group and independent work activities for Grades R to 3 (Department of Basic Education, 2011b:11). Whole-class activities include “mental Mathematics, consolidation of concepts and classroom management (allocation of independent activities, etc.)” (Department of Basic Education,

2011b:11). Small-group teaching includes “counting, number concept development (oral and practical activities), problem-solving (oral and practical activities), written recording, developing calculating strategies (oral and practical activities), patterns, space and shape, measurement and data handling” (Department of Basic Education, 2011b:11). According to the Department of Basic Education (2011b:11), independent work is when learners practise and consolidate concepts developed during the other two types of activities.

The CAPS policy document emphasises integration and play-based learning for Grade R learners (Department of Basic Education, 2011b:13). The policy encourages the holistic development of learners by using “imaginative play, outdoor play and playground games” (Department of Basic Education, 2011b:13). In the CAPS policy document, a structure for a daily programme for Grade R learners is provided, with great focus on play (see Figure 4-40 below). The CAPS document no longer focuses on play-based learning for learners in Grades 1 to 3, as in the case of Grade R (Department of Basic Education, 2011b:13). The ATP for Mathematics only prescribes whole-class activities and independent work activities (Department of Basic Education, 2021a:1).

As mentioned above (see Section 4.6.1), based on the observation of cases (classrooms), 9% of the participating classrooms from Farm schools, 36.8% of those in the Township schools and 80% of those in the Model C school had toys available in the classroom for open and unstructured play. The classroom design is divided between a classical and a group design. Of the observed cases, in 72.7% of the classrooms in the Farm schools, 63.2% of the classrooms in the Township schools and 80% of the classrooms in the Model C school, desks are placed in a classical arrangement – learners at single desks or in pairs where the desk permits (see Figure 4-36 for a classroom map of a classical arrangement). Of the observed cases, in 27.3% of the classrooms of the Farm schools, 36.8% of the classrooms of the Township schools and 20% of the classrooms of the Model C school, desks are placed in a small-group arrangement (see Figure 4.37 for a classroom map of a small-group arrangement). Furthermore, 33.3% of the Farm schools, 50% of the Township schools and the Model C school (i.e. 100%) from which data were gathered had some form of outdoor play area for learners.

Although policy documents mostly prescribe the use of different approaches for Grade R learners, teachers of Grades R to 3 make use of different approaches when teaching Mathematics. From the researcher’s observations of the classroom arrangement, most of the classrooms are not arranged in a manner that supports learners working in small groups. Due to the restrictions set by the Department of Basic Education during the Covid-19 pandemic, this observation of the classroom arrangement in the classrooms of the participants may differ from what the participants prefer. Even with the rules and regulations of the Covid-19 pandemic, teachers still regard activities such as working in small groups as important. Although the teachers indicated that they

often made use of free-play activities inside and outside, it was clear from the observations that the participating Farm and Township schools were not well equipped for these types of activities.

MATHEMATICS GRADE 1-3

**Figure 1: Grade R daily programme
(From ± 7:30 - 13:00)**

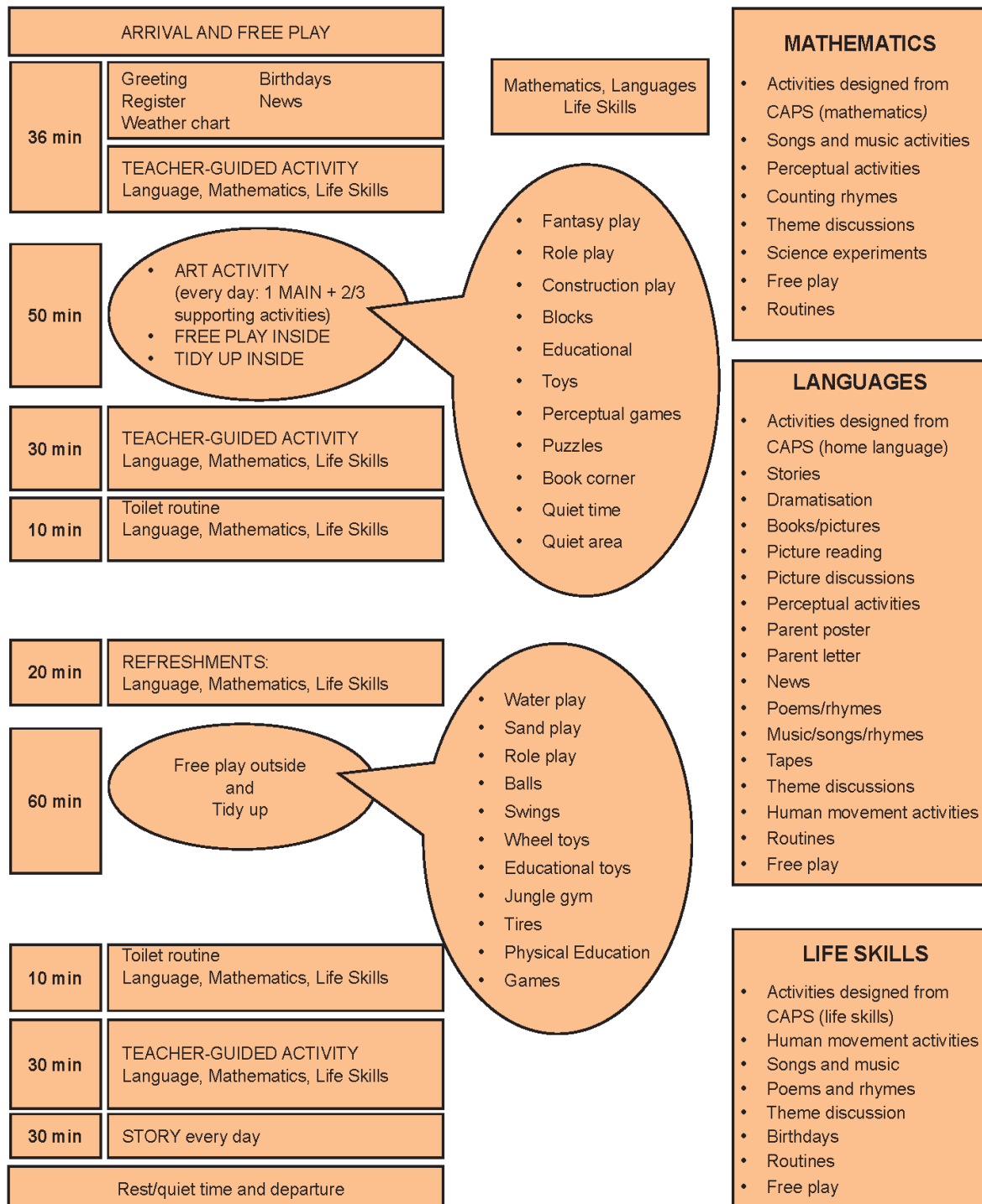


Figure 4-40: Grade R daily programme (extracted from Department of Basic Education, 2011b:15)

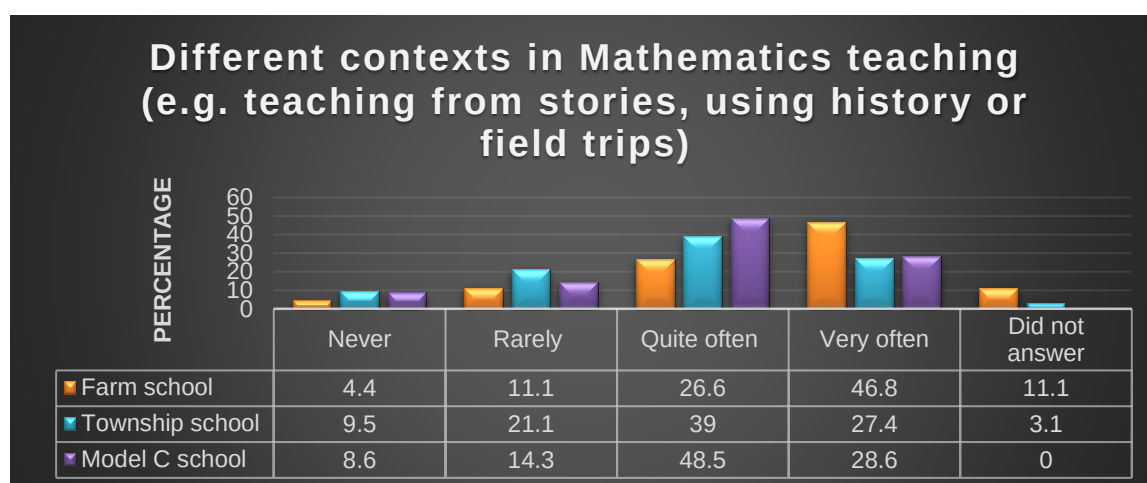


Figure 4-41: Using different contexts in Mathematics teaching

Of the participating teachers, 4.7% opted not to answer the question. The remaining participants indicated that they often made use of different contexts to teach Mathematics. The participants from the Farm schools indicated that they more often made use of different contexts to teach Mathematics than the participants from the other schools.

As seen in the previous discussion above, the CAPS policy document prescribes a play-based methodology for Grade R learners (Department of Basic Education, 2011b:13). To further the holistic development of Grade R learners, the policy encourages their development by using “stories, songs, rhymes, finger games and water play, educational toys including board games, construction and exploration activities (mass, time, capacity, measurement, etc.)” (Department of Basic Education, 2011b:13). These contexts are not mentioned further in the CAPS document for Grades 1 to 3. The ATP policy document does not mention different kinds of contexts other than providing learners with word problems (Department of Basic Education, 2021a:2).

Although the use of different contexts is not prescribed by the policy documents for Grades 1 to 3, teachers often make use of different contexts when teaching Mathematics, for example using word problems, stories or rhymes and play money (Department of Basic Education, 2021e:3). It should be noted that at the time of this inquiry, the Covid-19 regulations influenced the inclusion of activities such as field trips.

4.6.3 Question 17 of the adapted Creative Little Scientists questionnaire

Question 17 was “How often do you encourage learners to undertake the following activities in **SCIENCE**?” See Table 4-31 below for a breakdown of the sub-questions and the Likert scale.

Table 4-31: Inquiry activities in Science

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe natural phenomena such as the weather or a plant growing and describe what they see				
b. Ask questions about objects, organisms and events in the environment				
c. Design and conduct simple investigations or projects				
d. Use data to construct reasonable explanations				
e. Communicate the results of their investigations and explanations				

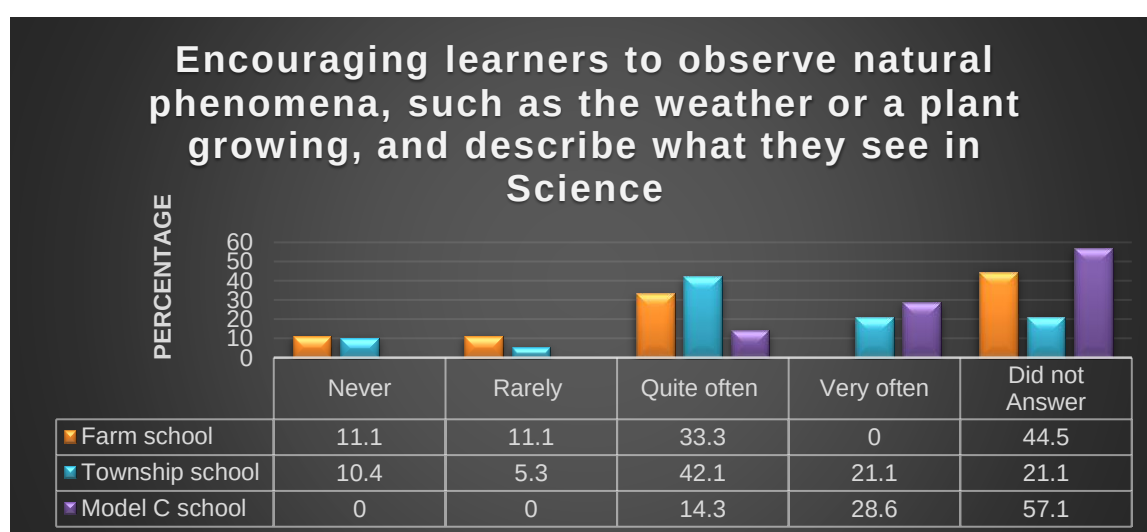


Figure 4-42: Encouraging learners to observe phenomena in Science

A total of 40.9% of the participating teachers opted not to answer the question. The remaining participants indicated that they often encouraged learners to observe natural phenomena. The participants from the Model C school indicated that they encouraged learners to do this activity more often than the participants from the other schools (see Figure 4-42).

Although the CAPS document (Department of Basic Education, 2011a:13) for Life Skills (integrated subject containing Science content) does not directly prescribe that teachers use activities that encourage the observation of natural phenomena, observation falls under the list of skills and values prescribed in the ATP policy document (Department of Basic Education, 2011a:13; 2021c:14-22). Teachers are encouraged to be aware of activities where self-regulation, discussions, exploration, inquiry (find out), problem solving, thinking and reasoning are developed (Department of Basic Education, 2021c:14-22). Although the ATP policy documents prescribe the fostering of different skills and values under each CAPS topic, the documents do not provide teachers with activities that foster each skill and value.

An example of an activity that fosters the observation of phenomena can be seen in the ATP policy document for Life Skills Grades 1 to 3 where there is an emphasis on learners observing the weather (Department of Basic Education, 2021c:14-22). This type of observation is prescribed as a daily activity in all four terms for learners in Grades 1 to 3. Weather is prescribed to be taught until learners can observe weather on their own and complete a weather chart. This includes knowledge with regard to “predictions, minimum and maximum temperature, symbols (Celsius, weather forecast) and cloud cover” (Department of Basic Education, 2021c:14-22).

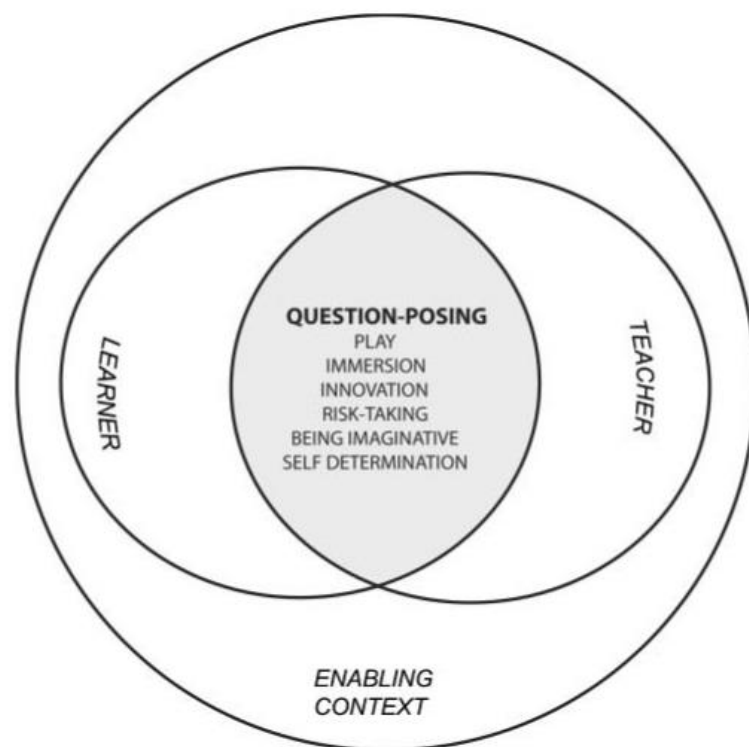


Figure 4-43: Fostering of skills and values (Chappell, Craft, Burnard & Cremin, 2008:269)

As seen in Figure 4-.43 above Chappell *et al.* (2008:268) suggest that the activities, as prescribed in the policy documents for Life Skills, encourage the interaction between teachers and learners and foster values and skills within specific contexts.

Both the CAPS and ATP policy documents prescribe activities that support learners in acquiring skills such as observing phenomena.

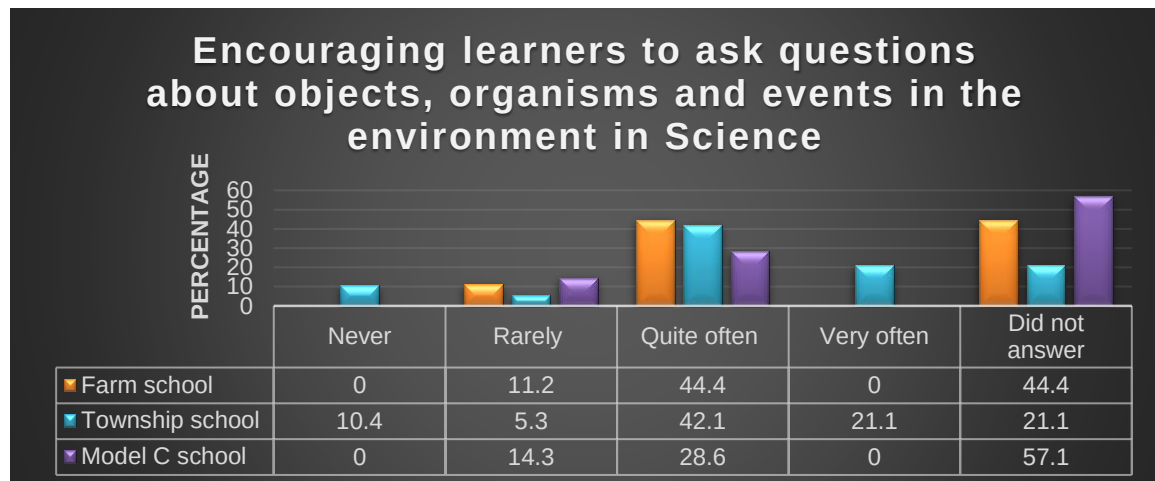


Figure 4-44: Encouraging learners to ask question in Science

A total of 40.9% of the participating teachers opted not to answer the question. The remaining participants indicated that they often encouraged learners to ask questions about objects, organisms and events in the environment in Science (see Figure 4-44).

The ATP document for Life Skills (integrated subject containing Science content) does not indicate specific activities that encourage learners to ask questions about objects, organisms and events in the environment (Department of Basic Education, 2021c:14-22). Teachers are, however, encouraged to be aware of activities where “self-regulation, discussions, exploration, inquiry (find out), problem solving, thinking and reasoning are developed” (Department of Basic Education, 2021c:14-22). The ATP policy document lists possible skills and values that can be fostered under specific CAPS topics but does not provide guidelines for teachers on how to foster these skills and values (Department of Basic Education, 2021c:14-22).

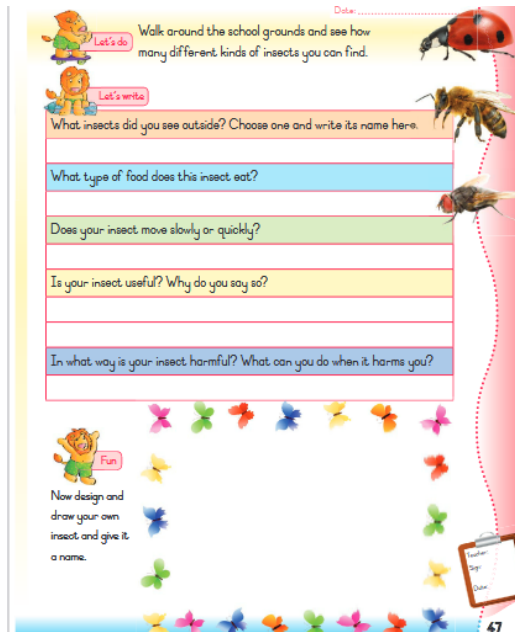


Figure 4-45: Example from Grade 2 Department of Basic Education learner workbook (Department of Basic Education, 2019:47)

Even though the policy document does not provide clear instructions on how to encourage learners to ask questions about objects, organisms and events in the environment, activities that enforce these skills are found in the prescribed workbooks. Figure 4-45 above shows an example where learners need to ask questions about insects.

As seen, the policy documents prescribe encouraging the development of specific skills under each topic, and activities that foster these skills are given in the prescribed workbooks for learners. The results from the participants confirm that asking questions about objects, organisms and events in the environment often occurs in classrooms.

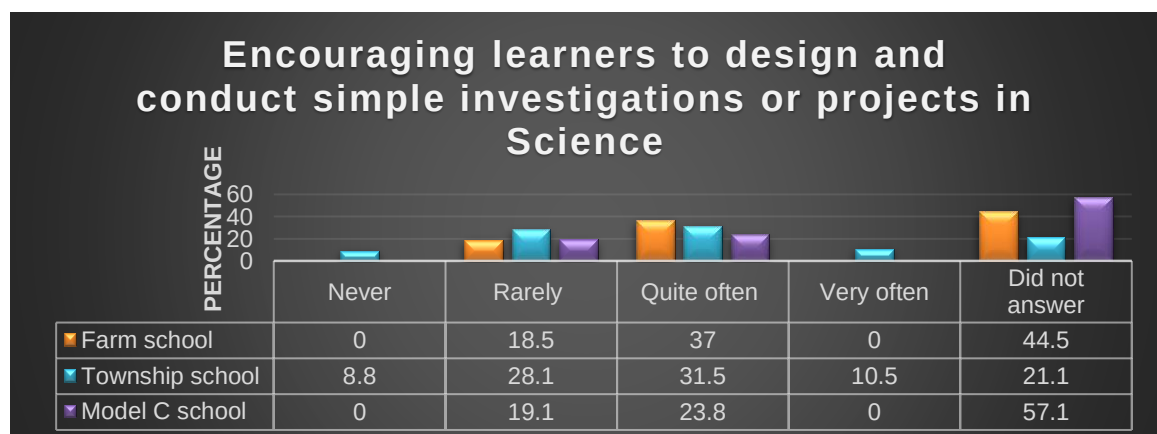


Figure 4-46: Encouraging learners to design and conduct investigations in Science

Of the participating teachers, 40.9% opted not to answer the question. The remaining participants indicated that they often encouraged learners to design and conduct simple investigations or projects in Science. Almost equal percentages of the participants from Township schools and the Model C school indicated that they rarely encouraged learners to design and conduct simple investigations or projects in Science.

The ATP document for Life Skills (integrated subject containing Science content) lists skills and values that teachers should encourage and develop under each of the CAPS topics (Department of Basic Education, 2021c:14-22). Although the document does not provide teachers with specific activities or guidelines on how to foster such skills or values, the prescribed Department of Basic Education workbook provides activities that encourage the development of these skills (Department of Basic Education, 2019:44). See Figure 4-47 below for an example of a simple investigation activity.



Figure 4-47: Example from Grade 2 Department of Basic Education learner workbook (Department of Basic Education, 2019:44)

As seen, the policy documents prescribe encouraging the development of specific skills under each topic, and activities that foster these skills are given in the prescribed learner workbooks.

The results from the participants confirm that there are some activities that encourage learners to design and conduct simple investigations or projects; however, they are not frequent.

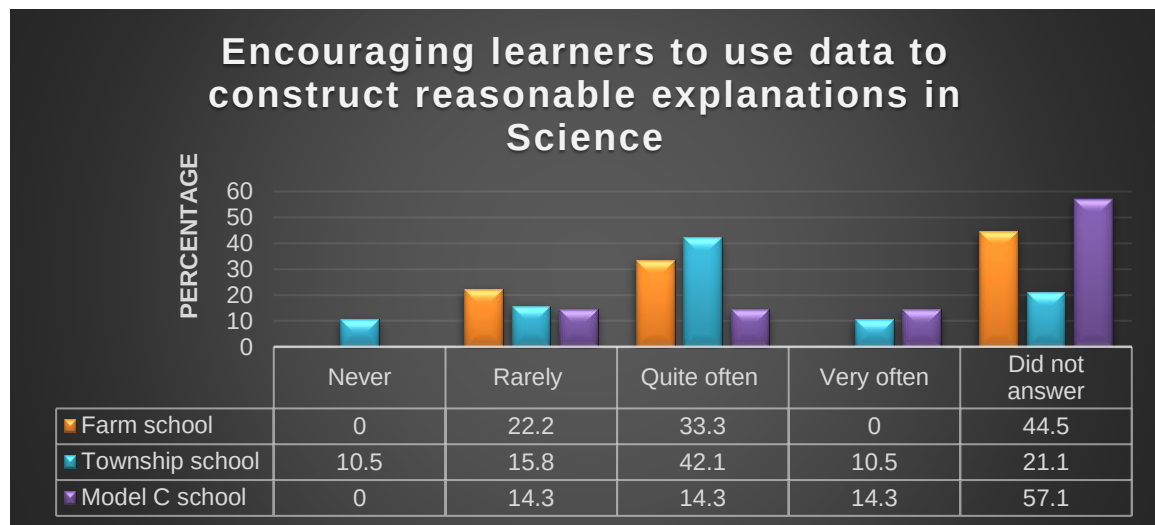


Figure 4-48: Encouraging learners to use data to construct reasonable explanations in Science

A total of 40.9% of the participating teachers opted not to answer the question. The remaining participants indicated that they often encouraged learners to use data to construct reasonable explanations in Science (see Figure 4-48).

As mentioned in the previous discussion, the policy documents provide teachers with a list of skills and values that should be developed in learners. This development is prescribed to take place under a specific CAPS topic (Department of Basic Education, 2021c:14-22). Although clear activities or guidelines for the fostering of the skills and values are not provided in these documents, activities that foster these skills and values are provided in the learners' prescribed workbooks. As seen in Figure 4-45 above, the learners need to make use of knowledge about insects to state an argument about why they are harmful and useful.

As seen, the policy documents prescribe that teachers encourage the development of skills such as "exploration, inquiry (finding out), problem solving, thinking and reasoning" under each CAPS topic, and activities that foster these skills can be found in the prescribed workbooks for learners. The results from the participants confirm that there are some activities that encourage learners to use data to construct reasonable explanations.

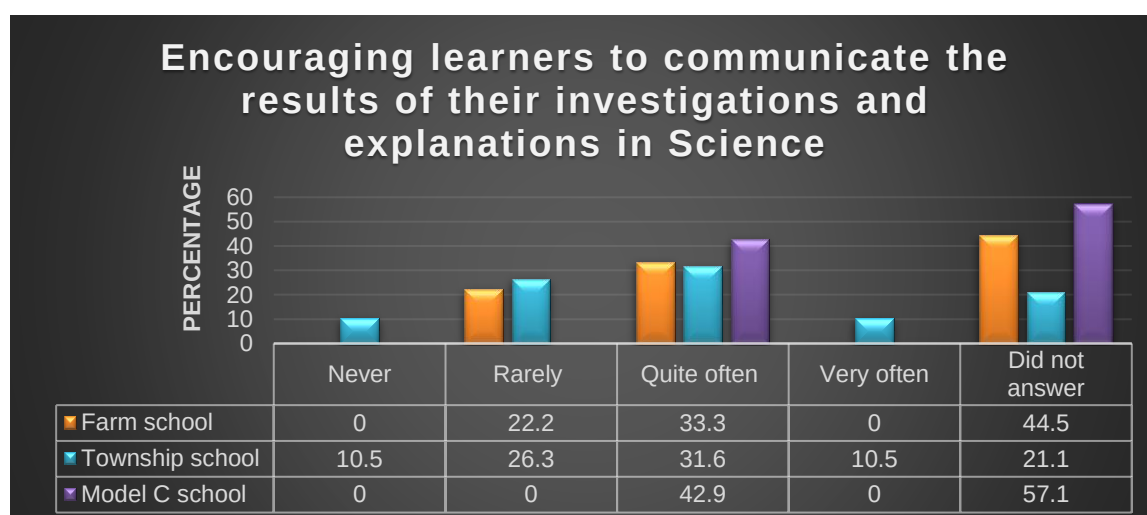


Figure 4-49: Encouraging learners to communicate their results in Science

A total of 40.9% of the participating teachers opted not to answer the question. The remaining participants indicated that they often encouraged learners to communicate the results of their investigations and explanations in Science (see Figure 4-49).

As seen in the previous discussion above, the Life Skills (integrated subject containing Science content) subject provides learners with activities in their prescribed workbooks that encourage the development of specific skills and values. Teachers are not specifically prescribed activities or guidelines on how to foster these skills or values but can choose when to encourage the development of such skills when doing the activities prescribed by the ATP and CAPS policy documents.

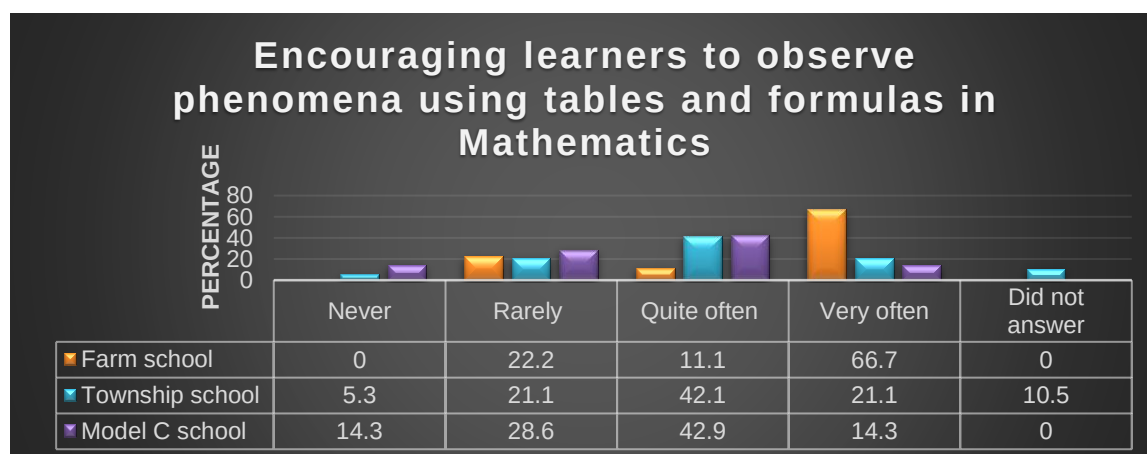
As seen, the policy documents prescribe that teachers encourage the development of skills such as discussions and communication under specific CAPS topics. The results from the participants confirm that some of the prescribed activities encourage learners to communicate the results of their investigations and explanations in the classroom.

4.6.4 Question 18 of the adapted Creative Little Scientists questionnaire

Question 18 was “**How often do you encourage learners to undertake the following activities in MATHEMATICS?**”. See Table 4-32 below for a breakdown of the sub-questions and the Likert scale.

Table 4-32: Inquiry activities in Mathematics

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe phenomena using tables and formulas				
b. Ask questions about objects and events about mathematic content in real life situations				
c. Design and conduct simple investigations or projects				
d. Use data to construct reasonable explanations				
e. Communicate the results of their investigations and explanations				

**Figure 4-50: Encouraging learners to observe phenomena in Mathematics**

Of the participating teachers, 3.5% opted not to answer the question. The remaining participants indicated that they often encouraged learners to observe natural phenomena in Mathematics. The participants from Farm schools indicated that they more often encouraged learners to do this activity than the participants from the other schools (see Figure 4-50).

The CAPS policy document for Mathematics prescribes that Grade R teachers should make use of the incidental learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13). However, this document does not mention the fostering of skills and values for Mathematics in Grades 1 to 3 (Department of Basic Education, 2011b:11). Although the ATP policy document for Mathematics includes a section on core concepts, skills and values that need to be addressed within the curriculum content for Mathematics, it focuses on listing the core

concepts and does not provide teachers with a list of values to foster in learners (Department of Basic Education, 2021a:1-2).

Even though the policy documents do not prescribe activities such as the observation of phenomena, activities that encourage and foster observation can be seen in the learners' prescribed workbooks. For example, in Grade 1, learners need to collect and sort everyday physical objects, then represent the sorted collection of objects and answer questions about the data (Department of Basic Education, 2011b:55). The results from the participants confirm that these types of activities take place often.

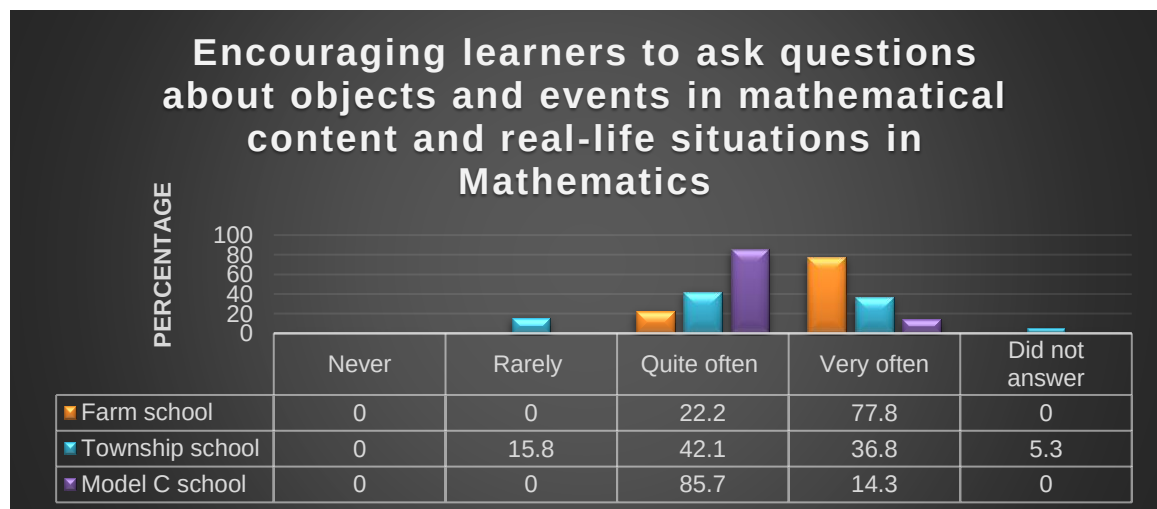


Figure 4-51: Encouraging learners to ask questions in Mathematics

Of the participating teachers, 1.8% opted not to answer the question. The remaining participants indicated that they often encouraged learners to ask questions about objects and events in Mathematic content and real-life situations in Mathematics. The participants from Farm schools indicated that they more often encouraged learners to perform this activity than the participants from the other schools (see Figure 4-51).

The ATP policy document for Mathematics includes a section for core concepts, skills and values that need to be addressed (Department of Basic Education, 2021a:1-2). However, the document only lists the core concepts that should be taught and does not provide teachers with a list of skills and values to foster in learners under specific CAPS topics (Department of Basic Education, 2021a:1-2).

Even though the policy documents do not prescribe specific activities to encourage asking questions about objects and events within Mathematic content and real-life situations, examples of activities that support this skill can be found in the prescribed learner workbooks. Figure 4-52

below provides an example from the Department of Basic Education learner workbook where learners are asked to share a pie. The results from the participants support that these types of activities take place often.

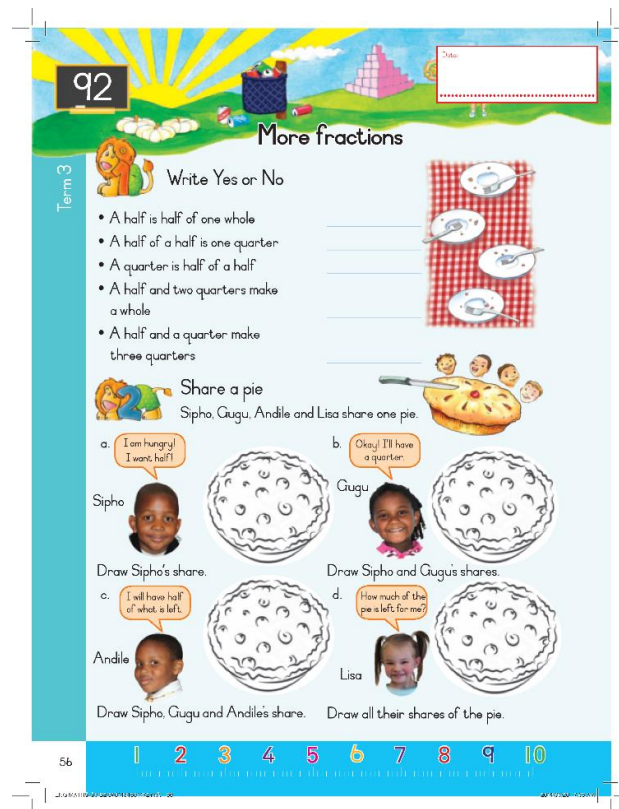


Figure 4-52: Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:56)

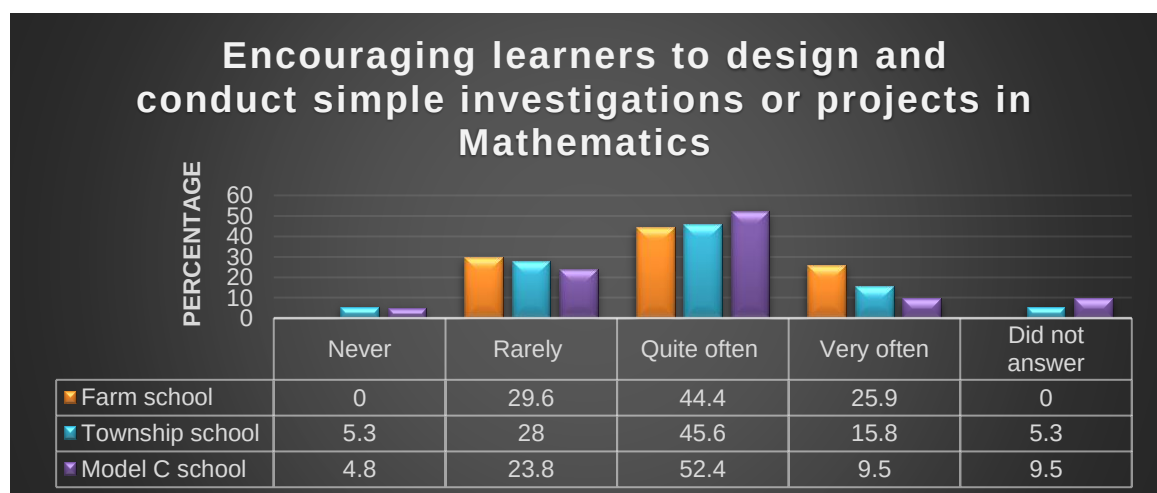


Figure 4-53: Encouraging learners to design and conduct investigations in Mathematics

Of the participating teachers, 4.9% opted not to answer the question. The remaining participants indicated that they often encouraged learners to design and conduct simple investigations or projects in Mathematics (see Figure 4-53).

The CAPS policy document prescribes that it is essential that learners learn to pose and solve problems (Department of Basic Education, 2011b:8). Even though the CAPS policy document does not specifically provide teachers with activities that encourage learners to design and conduct simple investigations, examples of activities that support the development of this skill can be found in the learner worknook (Department of Basic Education, 2011b:50). See Figure 4-54 below for an example of where learners are asked to investigate which of the objects can roll, which can slide and which can be stacked. The results from the participants support that these types of activities take place often.

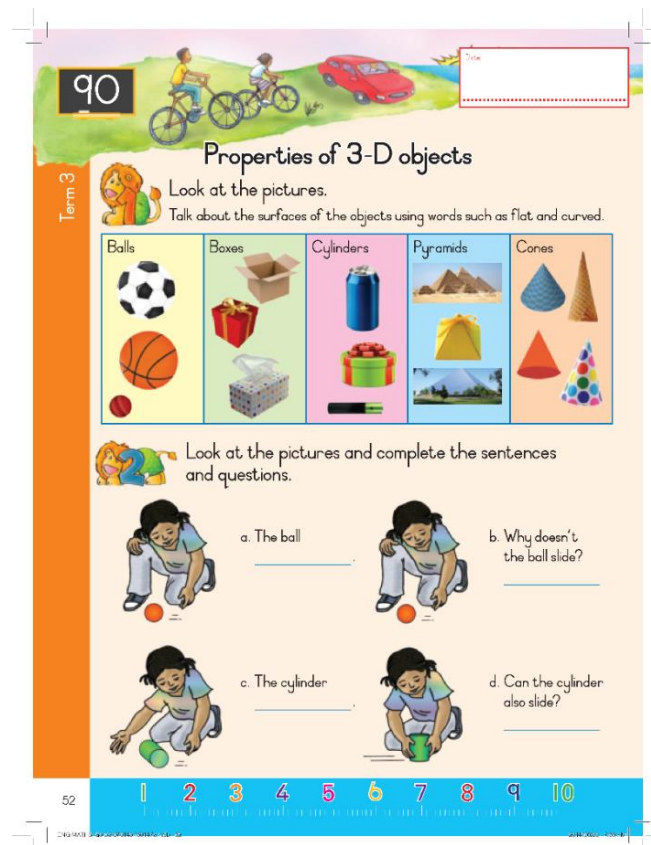


Figure 4-54: Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:52)

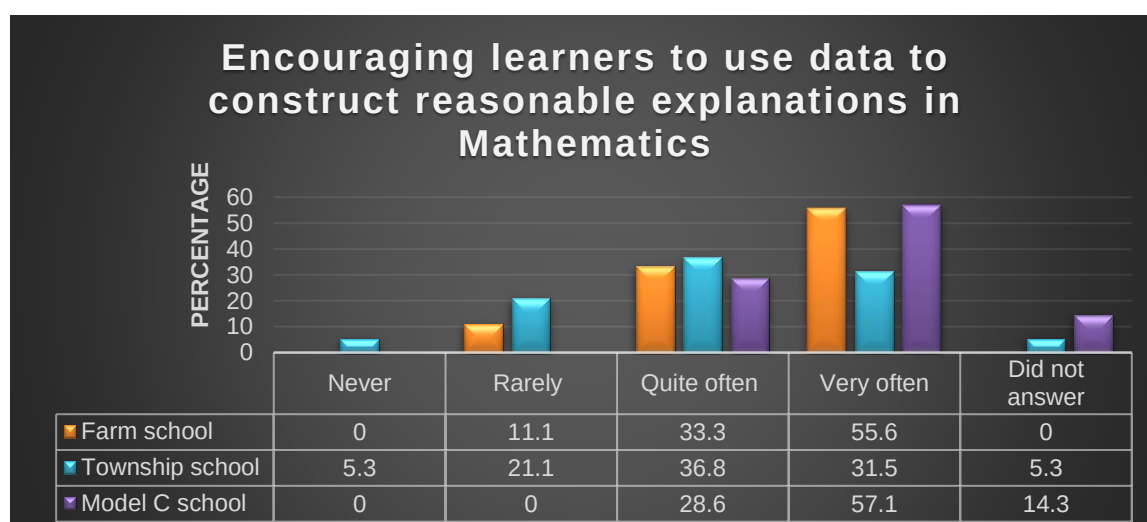


Figure 4-55: Encouraging learners to use data to construct reasonable explanations in Mathematics

Of the participating teachers, 6.5% opted not to answer the question. The remaining participants indicated that they often encouraged learners to use data to construct reasonable explanations in Mathematics. The participants from Township schools reported that they less often encouraged learners to perform this activity than the participants from the other schools (see Figure 4-55).

The CAPS policy document prescribes essential skills that learners should develop in the Mathematics subject, namely to learn to listen, communicate, think, reason logically and apply the mathematical knowledge gained (Department of Basic Education, 2011b:8). Even though the CAPS policy document does not specifically prescribe activities that encourage learners to use data to construct reasonable explanations, examples of activities that support the development of this skill can be found in the learner workbook (Department of Basic Education, 2011b:58). These types of activities often include word problems that provide data that need to be used in order to arrive at the answer within the provided context (see Figure 4-56 below). The results from the participants support that these types of activities often take place.



Figure 4-56: Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:18)

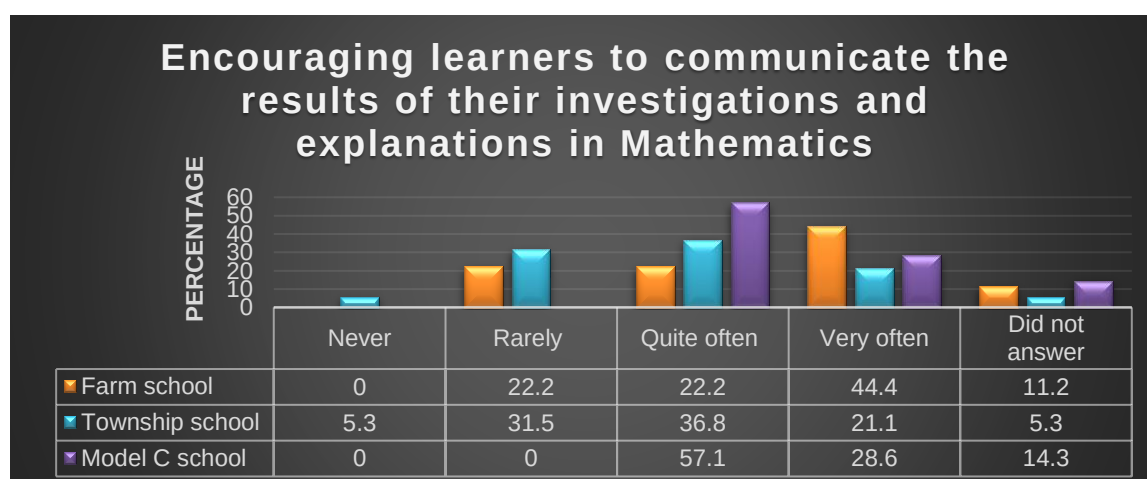


Figure 4-57: Encouraging learners to communicate their results in Mathematics

A total of 10.3% of the participating teachers opted not to answer the question. The remaining participants indicated that they often encouraged learners to communicate the results of their investigations and explanations in Mathematics (see Figure 4-57).

As mentioned in the previous discussion, the CAPS policy document prescribes essential skills that learners should develop in Mathematics, which include learning to communicate (Department of Basic Education, 2011b:8). Although the CAPS policy document does not specifically prescribe that teachers encourage learners to communicate the results of their investigations and explanations, examples of activities that support the development of this skill can be found in learner work (Department of Basic Education, 2011b:58). See Figure 4-58 below for an example

of where learners are asked to complete a map and then use that map to provide directions to their friends.

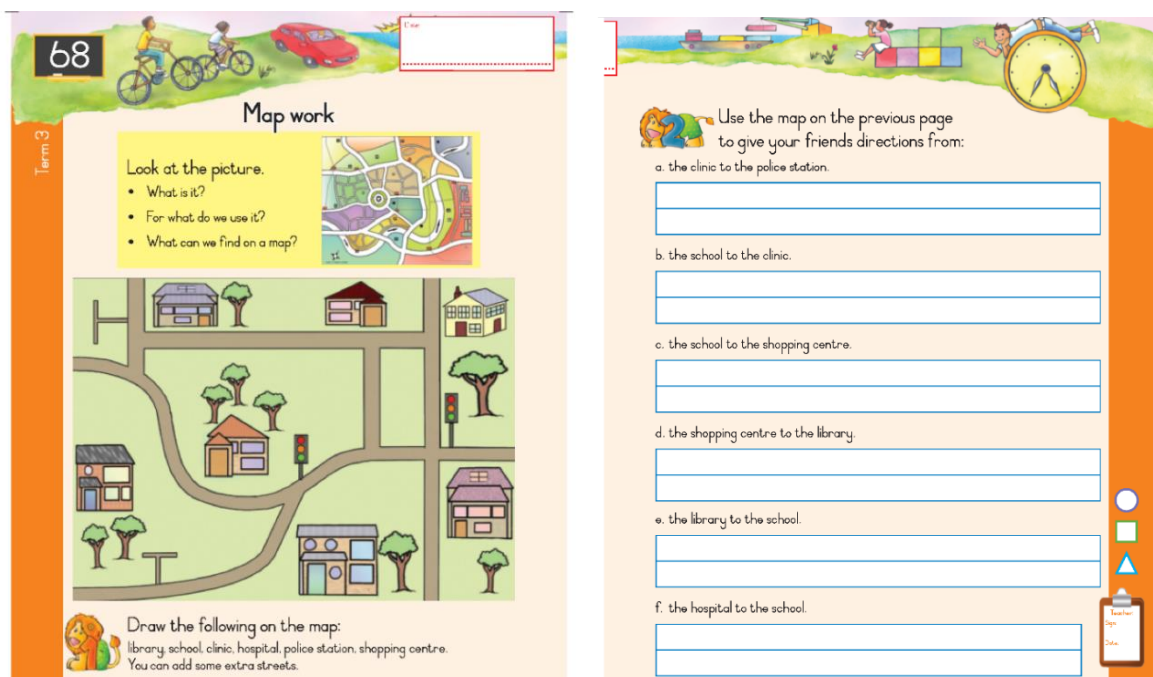


Figure 4-58: Example from Grade 3 Department of Basic Education learner workbook (Department of Basic Education, 2017:10-11)

4.6.5 Question 19 of the adapted Creative Little Scientists questionnaire

Question 19 was “For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the SCIENCE classroom. (Please indicate your choice on the block with the description)”. See Table 4-33 below for a breakdown of the Likert scale.

Table 4-33: Approach of inquiry in the Science classroom

	A (Open)	B (Guided)	C (Structured)	N/A
a. Inquiry features: question, evidence, analyse, explain, connect, communicate and reflect	Learner determines question, data collection, analysis, formulation, resources, communication and reflection	Learner selects from a range of questions and way of data collection, analysis, formulation, resources, communication and reflection given by teacher	Learner is given a question and the way of data collection, analysis, formulation, resources, communication and reflection by the teacher	

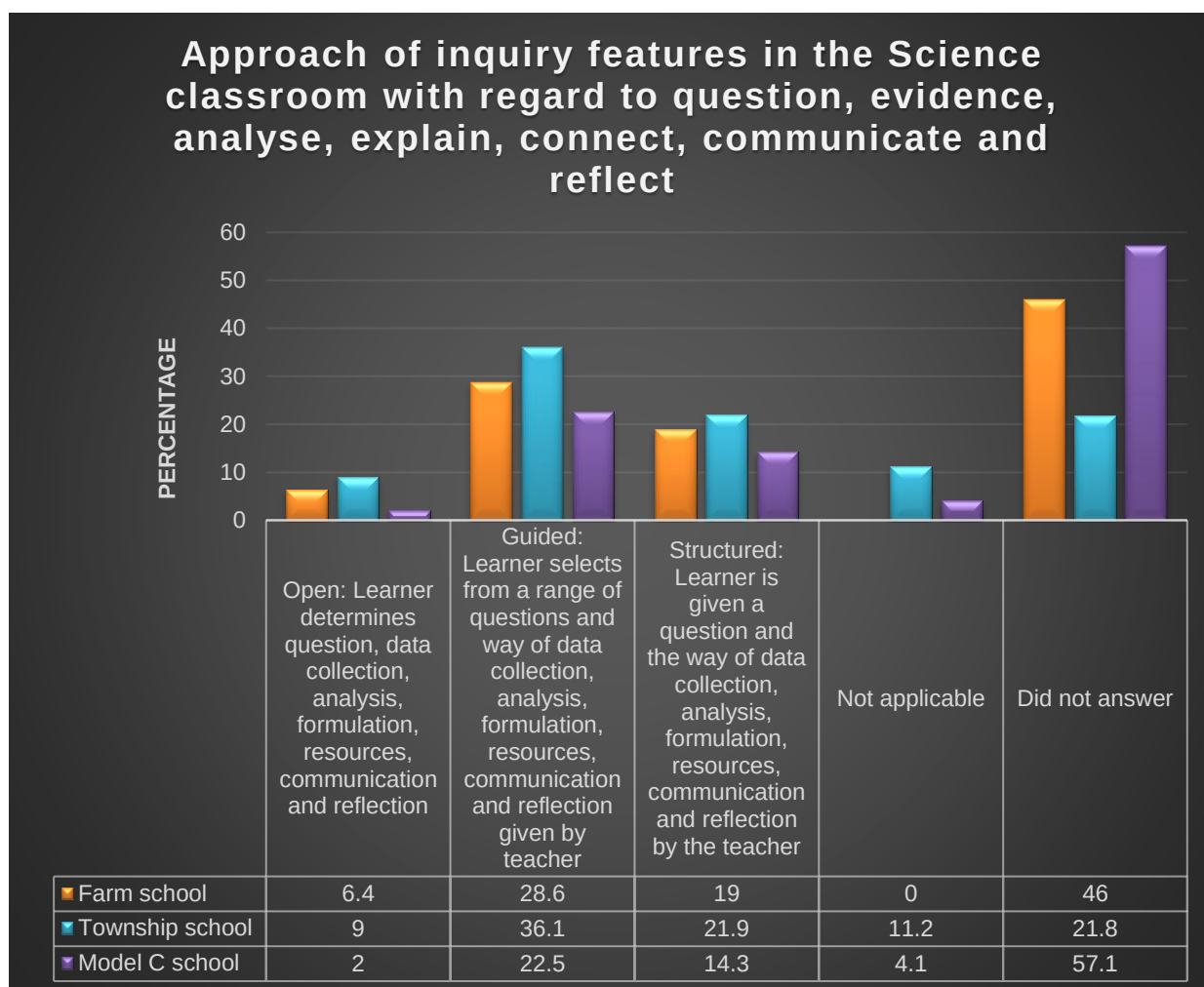


Figure 4-59: Approach of inquiry followed in the Science classroom

A total of 41.6% of the participating teachers opted not to answer the question. The remaining participants indicated that they preferred a guided approach in dealing with inquiry features.

The CAPS policy document for Life Skills (integrated subject containing Science content) prescribes two types of activities for learners in Grades R to 3, namely free-play and structured activities. Free-play activities are most often used for the learning areas of Creative Arts and Physical Education using activities within, for example, free art, fantasy play, book area, discovery area or sensory play, Whilst structured activities are activities often guided by the teacher and relate to concepts, content and skills (listed in the APT policy document) that learners should develop (Department of Basic Education, 2011a:13). These skills and values include “investigating, processing, communicating, inquiring, comparing and classifying” as examples. Teachers are encouraged to be aware of activities where “self-regulation, discussions, exploration, inquiry (finding out), problem solving, thinking and reasoning” are developed (Department of Basic Education, 2021c:14-22). Although both the CAPS and the ATP policy

documents prescribe the fostering of different skills and values under each CAPS topic, the documents do not provide guidelines for teachers on the approach to be used.

Although the education policy prescribes skills and values that should be fostered by teachers that include the development of inquiry in learners, the policy documents do not indicate how teachers should teach these skills and values. From the above data, it is seen that teachers prefer to use guided approaches in activities where they provide learners with sets of choices rather than allowing learners to decide on their own process of inquiry.

4.6.6 Question 20 of the adapted Creative Little Scientists questionnaire

Question 20 was “**For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the MATHEMATICS classroom. (Please indicate your choice on the block with the description)**”. See Table 4-34 below for a breakdown of the Likert scale.

Table 4-34: Approach of inquiry followed in the Mathematics classroom

	A (Open)	B (Guided)	C (Structured)	N/A
a. Inquiry features: question, evidence, analyse, explain, connect, communicate and reflect	Learner determines question, data collection, analysis, formulation, resources, communication and reflection	Learner selects from a range of questions and way of data collection, analysis, formulation, resources, communication and reflection given by teacher	Learner is given a question and the way of data collection, analysis, formulation, resources, communication and reflection by the teacher	

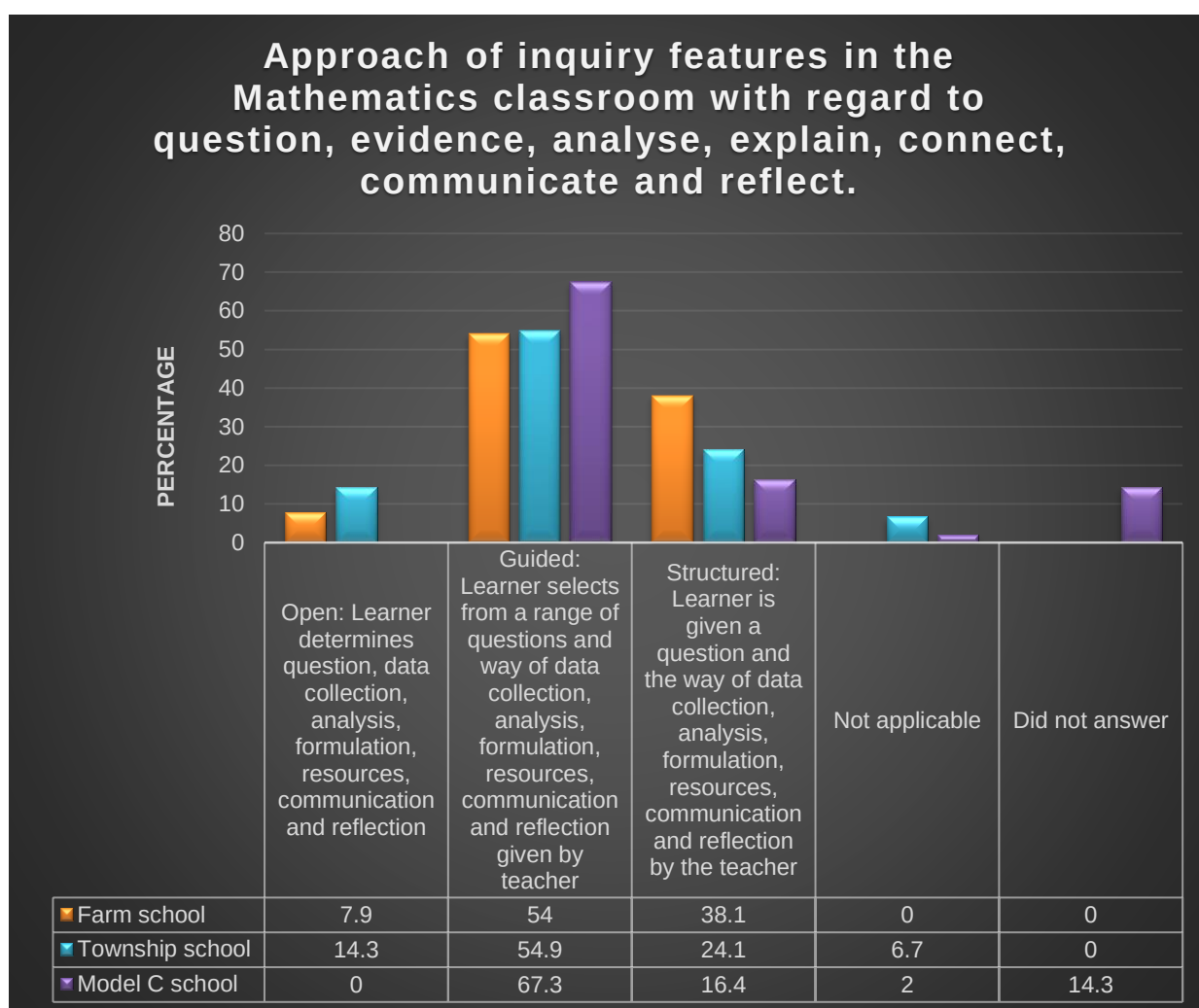


Figure 4-60: Approach of inquiry in the Mathematics classroom

Of the participating teachers, 4.8% opted not to answer the question. The remaining participants from all types of schools indicated that they preferred a guided approach when dealing with inquiry features.

The CAPS policy document for Mathematics prescribes that a Grade R teacher should act as a mediator and not a facilitator (Department of Basic Education, 2011b:13). The policy document describes mediation as making use of the incidental learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13).

The CAPS policy document for Mathematics provides suggested guidelines for classroom management using three types of activities for learners in Grades 1 to 3, namely whole-class activity, small-group teaching and independent work (Department of Basic Education, 2011b:11). The interpretation and approach followed by teachers in these types of activities are, however,

not prescribed in the policy document. There is no indication of fostering inquiry in the policy documents. Although the ATP policy document indicates a section where core concepts, skills and values to be taught to learners are listed, the document only focuses on listing the core concepts that learners should master under the above-mentioned section (Department of Basic Education, 2021a:1-2).

From the discussion above, it is seen that the policy documents does not directly indicate fostering inquiry in Mathematics. The policy, however, provides teachers in Grades 1 to 3 with classroom management guidelines that provide them with the opportunity to choose the best-suited approaches for teaching CAPS topics. With the approach to teaching CAPS topics open for interpretation, the results indicate that the teachers prefer to use guided approaches where they provide learners with sets of choices rather than allowing learners to decide on their own process of inquiry.

4.6.7 Question 21 of the adapted Creative Little Scientists questionnaire

Question 21 was “**How strongly do you agree or disagree with each of the following statements about the role of teacher in fostering INQUIRY skills?**”. See Table 4-35 below for a breakdown of the sub-questions and the Likert scale.

Table 4-35: Role of the teacher in fostering inquiry

	1 (Strongly disagree)	2 (Disagree)	3 (Agree)	4 (Strongly agree)
a. Teachers should demonstrate first the correct way to solve a problem				
b. Teachers should facilitate learners own inquiry and give ample time to work out their own solutions				

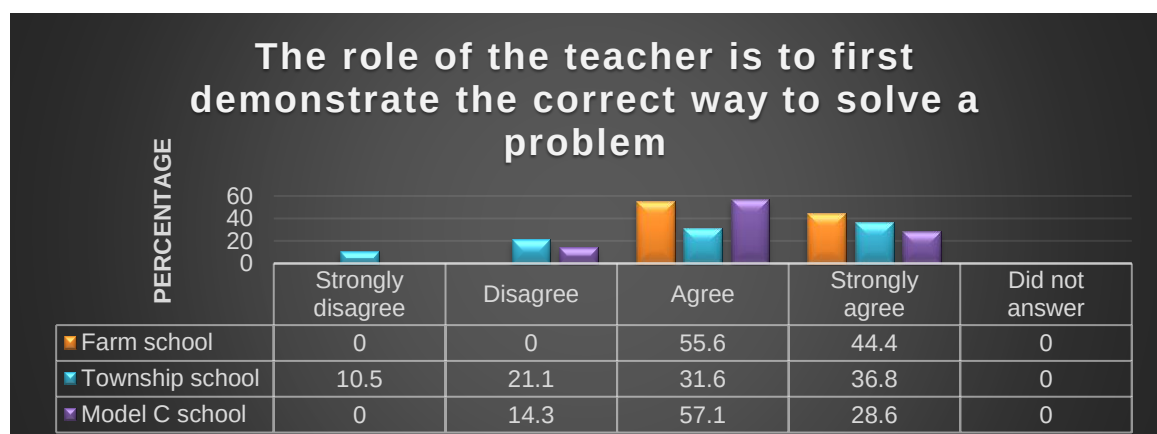


Figure 4-61: The role of the teacher is to first demonstrate the correct way to solve a problem

The participants indicated that they agreed that the role of the teacher should be to first demonstrate the correct way to solve a problem (see Figure 4-61).

The CAPS policy document for Life Skills (integrated subject containing Science content) prescribes two types of activities for learners in Grades R to 3, namely free-play and structured activities. Free-play activities are most often used for the learning areas of Creative Arts and Physical Education within the context of “free art, fantasy play, book area, discovery area, sensory play”, while structured activities are guided by the teacher and relate to concepts, content and skills (listed in the ATP policy document) that learners should develop (Department of Basic Education, 2011a:13). These skills and values include “investigating, processing, communicating, inquiring, comparing and classifying” as examples. Teachers are encouraged to be aware of activities where “self-regulation, discussions, exploration, inquiry (find out), problem solving, thinking and reasoning” are developed (Department of Basic Education, 2021c:14-22).

The CAPS policy document for Mathematics provides suggested guidelines for classroom management (Department of Basic Education, 2011b:11). These guidelines make use of three types of activities for learners in Grades 1 to 3, namely whole-class activity, small-group teaching and independent work (Department of Basic Education, 2011b:11). The policy document provides teachers with examples of these types of activities. Whole-class activities are prescribed at the beginning of the lesson where teachers ask mental Mathematics questions to the whole class, such as “what is the number before eight?” or “what is four plus two?”. In small-group activities, teachers are prescribed to work with eight to 12 learners of the same ability on the floor while the rest of the learners are engaged in independent activities. In small-group activities teachers can give learners “counting, estimation, problem-solving, measurement and data handling” activities (Department of Basic Education, 2011b:11). Independent activities are various activities that need to cater for the different levels of ability of learners. These activities consolidate what has been taught in the whole group and small groups (Department of Basic Education, 2011b:12). There is no indication in these guidelines whether teachers should demonstrate the correct methods or act as facilitators. The CAPS policy document for Mathematics, however, does prescribe that Grade R teachers should act as mediators and not facilitators (Department of Basic Education, 2011b:13). The policy document describes mediation as making use of the incidental learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13). From the above, it is seen that policy does not dictate the approach that teachers should use in teaching and learning activities.

Policy documents for Mathematics do not explicitly mention fostering inquiry in learners in Grades 1 to 3. Grade R teachers, however, are encouraged to mediate learning opportunities during play-based activities. The policy documents for Life Skills furthermore list skills and values that learners should develop under each CAPS topic. Under the skills and values listed, teachers are encouraged to develop inquiry in learners. The policy documents do not provide teachers with guidelines on how to teach and support the development of these skills and values.

Inquiry entails learners being independent, using their curiosity and skills to find out and evaluate specific content (Creative Little Scientists, 2012e:26). The question posed in the questionnaire was whether “the role of the teacher in fostering inquiry should take place by first demonstrating the correct way to solve a problem”. So, this question contradicts the idea of independent curiosity and work. Although this question is contradicting, the teachers indicated a strong agreement that they should first show learners how to correctly solve problems.

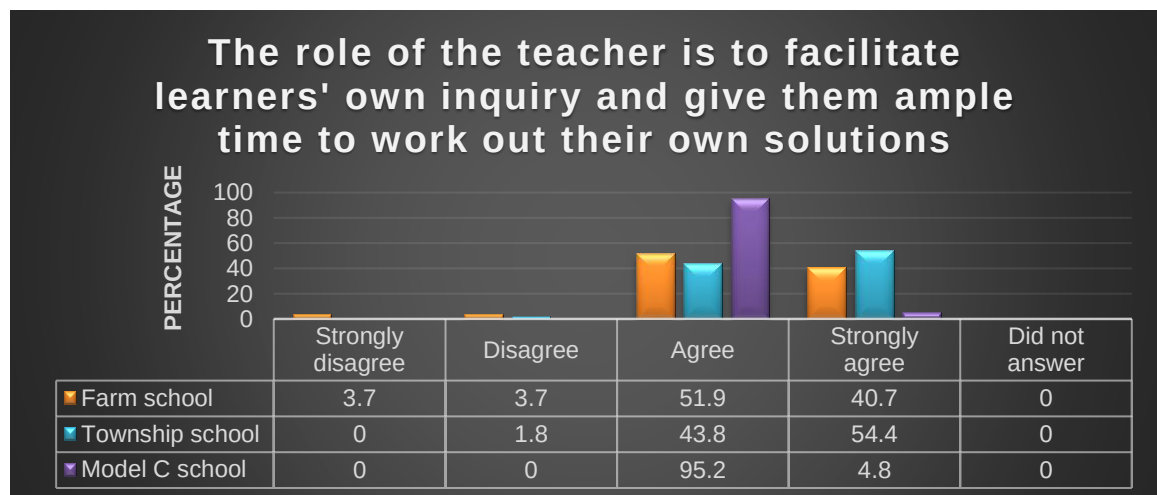


Figure 4-62: The role of the teacher is to facilitate learners’ own inquiry and give them ample time to work out their own solutions

The participants indicated that they agreed that the role of the teacher should be to facilitate learners’ own inquiry and give them ample time to work out their own solutions. The participants from the Model C school agreed less strongly with this than the participants from the other schools (see Figure 4-62).

As seen in the previous discussion of the role of the teachers, the policy documents for Life Skills (integrated subject containing Science content) encourage teachers to use activities where “self-regulation, discussions, exploration, inquiry (finding out), problem solving, thinking and reasoning” are developed (Department of Basic Education, 2021c:14-22). The CAPS policy documents for

Mathematics only prescribe guidelines for classroom management for learners in Grades 1 to 3 and give no indication of the role of the teacher (Department of Basic Education, 2011b:13). Grade R teachers are, however, encouraged to act as mediators rather than facilitators and make use of learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13).

The policy documents for Life Skills indicate that teachers should encourage learning opportunities where learners practise the development of inquiry. The policy documents for Mathematics, especially in Grades 1 to 3, do not give an indication that skills such as inquiry should be developed and rather focus on the core concepts of Mathematics. The participants agreed that the role of the teacher should be to facilitate learners' own inquiry and give them ample time to work out their own solutions in both subject areas. This result is in contrast to the previous discussion where the participants indicated that they held the perception that the role of the teacher was to first demonstrate the correct way to solve a problem.

4.6.8 Summary of the pedagogical phenomenon of instructional methodology

A summary of the results that emanated from Questions 15, 16, 17, 18, 19, 20 and 21 includes i) the use of instructional methods in the Science and Mathematics classrooms and ii) the role of the teacher when teaching Science and Mathematics.

- i. The overall results indicate that teachers from all three types of schools often make use of different approaches and contexts when teaching both Science and Mathematics. Furthermore, teachers from all three types of schools often encourage learners to observe, ask questions, design and conduct investigations, explain and communicate findings in both Science and Mathematics. Lastly, with regard to inquiry, teachers from all three types of schools indicated that they preferred to guide learners by letting them select from a few options rather than design their own methods.

The CAPS policy document for Life Skills (integrated subject containing Science content) suggests that the timetable for the Grade R to 3 (Foundation Phase) should consist of routine activities, free-play activities indoors and outdoors, as well as structured activities (Department of Basic Education, 2011a:10). The integrated nature of the Life Skills subject indicates the use of contexts and the fostering of different skills and values under various CAPS topics. The policy documents, however, leave the interpretation and choice of instructional method to the teacher. Teachers are encouraged through policy to be aware of activities where learners can develop "self-regulation, discussions, exploration, inquiry (find out), problem solving, thinking and reasoning", but these activities are not indicated

specifically under a topic (Department of Basic Education, 2021c:14-22). Although the policy documents indicate that teachers should be aware of activities where learners self-regulate their inquiry, teachers indicated that they still prefer to mainly guide learners in activities of inquiry.

The classrooms of most of the participating teachers are arranged in such a way that learners are sitting in rows instead of in groups (see Section 4.6.1, Figure 4-36). This seating arrangement of having learners sit in rows instead of groups is a reflection of the teachers' beliefs stated above that they prefer to guide learners in activities of inquiry. In other words, they do not feel the need to organise learners in groups where free discussion and self-regulated learning will be encouraged. According to the Covid-19 pandemic rules and regulations that had to be adhered to at the time this inquiry was conducted, learners were not allowed to share materials and had to maintain a distance of at least one meter from one another. These rules might have had an impact on the layout of the classrooms and the use of group work by prohibiting classroom arrangements that the teachers might prefer under normal circumstances.

The policy documents for Mathematics emphasise play-based learning for Grade R learners where they are encouraged to use imaginative play, outdoor play and playground play to develop them holistically (Department of Basic Education, 2011b:13). However, these documents do not provide an indication of play-based activities in Mathematics for learners in Grades 1 to 3 (Department of Basic Education, 2021a:1-3). Although play-based activities are no longer prescribed in Grades 1 to 3, the use of context and activities that encourage self-regulation and other features of inquiry is seen in the use of word problems and some activities in the prescribed workbook. As there is no suggestion of the approach that teachers should use when teaching Mathematics in policy documents, teachers prefer to guide learners in activities.

- ii. Teachers from all three types of schools agreed that the role of the teachers was to first demonstrate the correct way to solve a problem. They also agreed that the role of the teachers was to facilitate learners' own inquiry and provide opportunities for finding their own solutions. This is contradictory, seeing that inquiry does not imply demonstration.

The policy documents for Life Skills prescribe two types of activities for learners in Grades R to 3, namely free-play and structured activities. Structured activities are prescribed to be guided by teachers (Department of Basic Education, 2011a:13). With regard to free-play activities, the policy documents encourage teachers to be aware of activities where

learners can foster self-regulation and other features of inquiry (Department of Basic Education, 2011a:13; 2021c:14-22). The policy documents do not provide teachers with a clear indication of the role of the teacher in the classroom.

The policy documents for Mathematics prescribe guidelines for classroom management of learners in Grades 1 to 3, there is no clear indication of the role of the teacher in the classroom. Grade R teachers are, however, encouraged to act as mediators and make use of learning opportunities that arise during play-based activities (Department of Basic Education, 2011b:13).

The policy documents for the Life Skills subject, as seen above, prescribe activities where the teacher both guides or demonstrates and is encouraged to facilitate learners' self-regulation and other features of inquiry. From the discussion of the policy documents for Mathematics, it comes to the fore that only Grade R teachers are encouraged to mediate learners during activities. There is no further indication of the role of the teacher in the classroom. The data suggest that teachers both facilitate and guide or demonstrate learners' own learning in Mathematics in all three types of schools.

4.7 Pedagogical phenomenon: resources

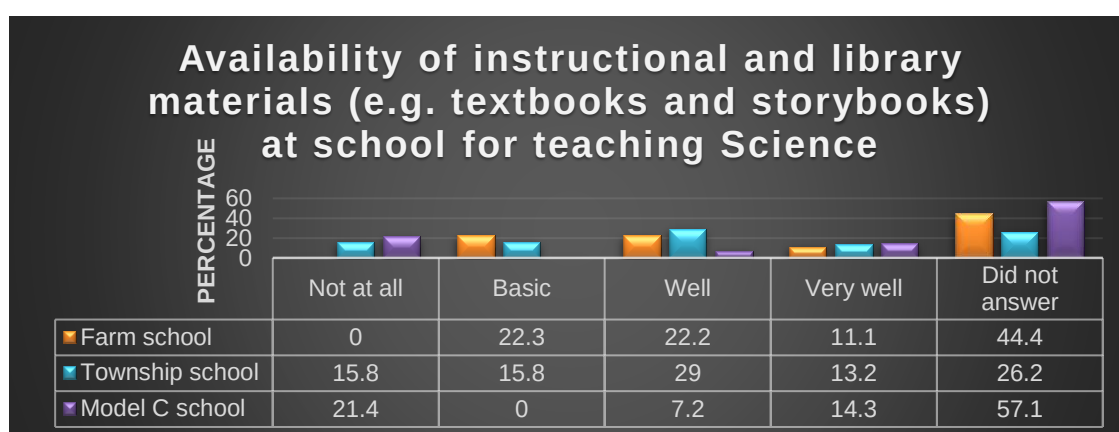
The following questions from the adapted Creative Little Scientists questionnaire provide data supporting the pedagogical phenomenon of resources in South Africa: Question 30 (the availability of resources for Science at the school), 31 (the availability of resources for Mathematics at the school), 32 (how often the available resources are used in the teaching of Science), 33 (how often the available resources are used in the teaching of Mathematics), 34 (what resources are consulted by the teacher in preparation for a Science lesson) and 35 (what resources are consulted by the teacher in preparation for a Mathematics lesson).

4.7.1 Question 30 of the adapted Creative Little Scientists questionnaire

Question 30 was "**How well resourced do you feel your school is for the teaching of SCIENCE in terms of the following?**" See Table 4-36 below for a breakdown of the sub-questions and the Likert scale.

Table 4-36: Resource available in school to teach Science

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional and library materials (e.g. textbooks and storybooks)				
b. Audio-visual and digital resources				
c. Equipment and materials for hands-on exploration inside and outside of the classroom				
d. Stationery (e.g. paper, drawing materials)				
e. Teaching support personnel (e.g. classroom assistant, technical support)				

**Figure 4-63: Availability of instructional and library materials at schools for teaching Science**

A total of 42.6% of the participating teachers opted not to answer the question. The participants from Farm and Township schools reported that their schools were well equipped with instructional and library materials. Interestingly, the participants from the Model C school indicated the same percentages for well (well and very well) and not at all (see Figure 4-63).

The CAPS policy document (Department of Basic Education, 2011a:12) prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities of Life Skills (integrated subject containing Science content). This document further provides teachers with a list of resources that will be needed in addition to the standard resources for the teaching and learning activities of specific topics. These resources include library or information books, pictures, flashcards, charts, posters and maps (Department of Basic Education, 2011a:15-65).

The ATP policy document provides teachers with a specific list of resources under each CAPS topic, as seen in Table 4-43 (Department of Basic Education, 2021c:14-22).

As seen above, the policy documents prescribe the availability and use of library materials in the teaching and learning activities of Life Skills. However, in 2021, only 30.41% of schools in South Africa had libraries, and only 17.39% of schools in South Africa had libraries that were stocked with material as seen in Table 4-37 below (Department of Basic Education, 2021b:7).

Table 4-37: Schools in South Africa with libraries (Department of Basic Education, 2021b)

Availability of libraries in South African schools (2021)					
Province	Number of schools in province	Schools with library	% with library	Schools with library with stocked material	% libraries stocked
Western Cape	1 457	800	54.91	449	30.82
Eastern Cape	5 291	355	6.71	215	4.06
Northern Cape	544	186	34.19	98	18.01
Free State	1 084	428	39.48	201	18.54
KwaZulu-Natal	5 803	1 408	24.26	1 005	17.32
North West	1 471	360	24.47	197	13.39
Gauteng	2 074	1 313	63.31	881	42.48
Mpumalanga	1 718	337	19.62	156	9.08
Limpopo	3 834	257	6.7	109	2.84
Total	23 276	5 444	30.41	3 311	17.39

Although the South African policy prescribes that teachers make use of instructional and library materials and provides teachers with a list of resources that are needed for the teaching and learning activities of Life Skills, the statistics of 2021 indicate that a mere 17.39% of schools in South Africa have functional libraries. From observations of the classrooms at the participating schools, 63.6% of the classrooms at the Farm schools, 42.1% of those at the Township schools and 100% of those at the Model C school had storybooks available for learners in the classroom (see Figure 4-64 below). All of the classrooms had textbooks or learner workbooks.



Figure 4-64: Map of the space observation – storybooks

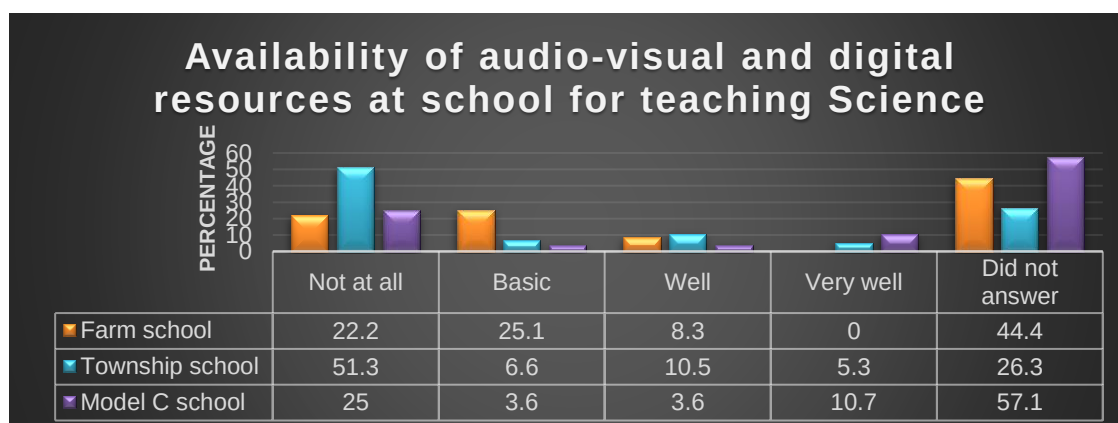


Figure 4-65: Availability of audio-visual and digital resources at school for teaching Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that their schools had no or only basic availability of audio-visual and digital resources for teaching Science. The majority of participants from Township schools indicated reported that their schools had no audio-visual and digital resources (see Figure 4-65).

As seen in the previous discussion, the CAPS policy document prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities of Life Skills (integrated subject containing Science content) (Department of Basic Education, 2011a:12). Although the policy document does not require teachers to use computers, computer applications or interactive whiteboards and cameras for teaching and learning, audio-visual equipment with a wide range of suitable music is prescribed for the Creative Arts section of Life Skills (Department of Basic Education, 2011a:13).

Although the policy documents do not prescribe the use of computers, computer applications or interactive whiteboards and cameras for teaching and learning activities directly, the use of pictures and stories is prescribed often. If there is no access to a library, teachers need to make use of other resources to acquire these materials and display them to learners. The NEIMS report indicates that only 41.8% of public schools in South Africa had computer centres in 2021 (see Table 4-38 below) (Department of Basic Education, 2021b). The NEIMS further reported that only 29,6% of public schools in South Africa had access to internet connectivity, with the majority of the schools with access situated in the Western Cape province (see Table 4-44) (Department of Basic Education, 2021b).

Table 4-38: Schools in South Africa with computer centres (Department of Basic Education, 2021b)

Availability of computer centres in South African schools (2021)			
Province	Number of schools in province	Schools with computer centres	% with computer centres
Western Cape	1 457	882	60.54
Eastern Cape	5 291	576	10.89
Northern Cape	544	288	52.94
Free State	1 084	431	39.76
KwaZulu-Natal	5 803	1 938	33.40
North West	1 471	667	45.34
Gauteng	2 074	1 662	80.14
Mpumalanga	1 718	657	38.24
Limpopo	3 834	575	15.00
Total	23 276	7 676	41.80

From the discussion above, it is clear that the majority of schools in South Africa do not have access to audio-visual and digital resources, with the further restraint of not having access to internet connectivity for teaching and learning activities. The data gathered from the participating schools and teachers support the lack of availability of these resources. Although all eight of the sites used for data generation have computer centres, the centres at seven of these sites are not in working order. Two of the eight sites make use of the computer centre as a regular classroom, with no audio-visual or digital resources in the classroom other than the smartboard. The remaining classrooms are equipped with a chalkboard and have no audio-visual or digital resources.

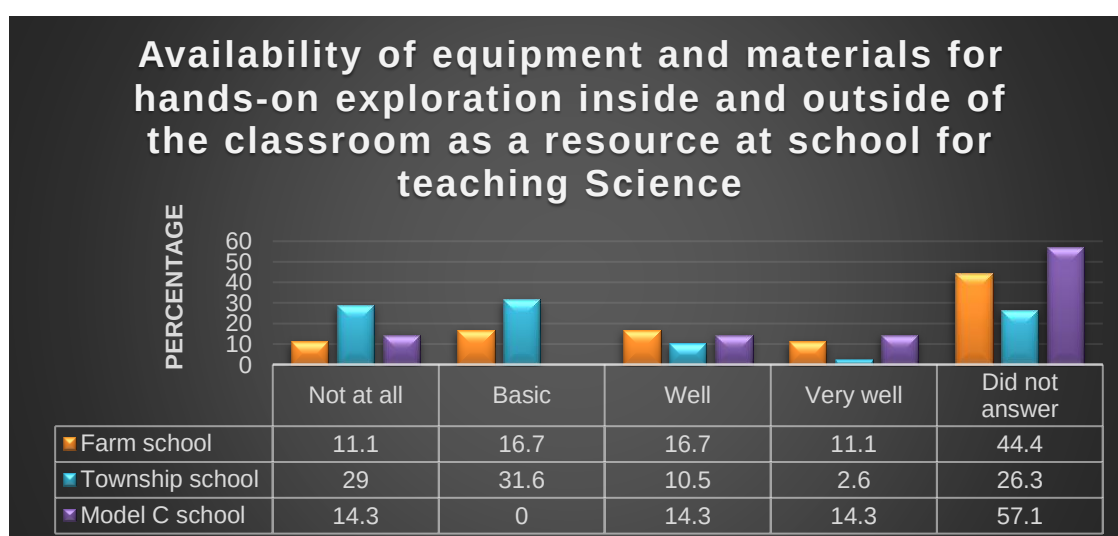


Figure 4-66: Availability of equipment at school for teaching Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants from the three different types of schools all indicated contrasting responses to the availability of equipment and materials at their schools. The participants from Farm schools reported the same percentage for both well (well and very well) and basic (not at all or basic). The participants from Township schools indicated basic, whereas the participants from the Model C school indicated that their school was well equipped (see Figure 4-66).

The CAPS policy document suggests activities for free play inside and outside the classroom in the subject of Life Skills (integrated subject containing Science content) for Grade R to 3 learners. Examples provided for free play inside are “free art, tearing, cutting, pasting, block area, fine motor activities, sand box, fantasy play, book area, discovery area, music area, writing area and block play” (Department of Basic Education, 2011a:11). Examples provided for free play outside are “water (and mud) play, sand play, sensory play, fantasy play, gross motor play, block play, ball play, wheel toys, construction, gardening, caring for animals and outside art activities” (Department of Basic Education, 2011a:11). For these activities, the CAPS policy document prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities of Life Skills (Department of Basic Education, 2011a:12). These resources for exploration inside and outside the classroom include the following: “ bean bags, ropes, hoops, balls of different sizes, balancing beams/planks/tyres, outdoor play equipment (tyres, jungle gym, climbing ropes, trees), scarves/strips of cloth, bats, containers (bowls, buckets, tins to be used as targets), skittles/bottles (as targets), hard, flat open surface, sticks, storage containers, swings, bricks, cones, balloons, beads (glass, paper, plastic), straws, macaroni, shells, etc. for threading, recyclable materials: boxes, toilet rolls, polystyrene containers and packing materials, corks, wrapping paper, tin foil, wool, string, stones, seeds, old newspapers/magazines, CD player, CDs, musical instruments, old clothes, utensils, containers, to be used as ‘props’ for fantasy and dramatic play, puzzles and other manipulative educational toys, bought and home made, plastic lens/ magnifying glass and visual stimuli for drawing and construction” (Department of Basic Education, 2011a:12-13).

The CAPS policy document further provides teachers with a suggested list of resources that will be needed in addition to the standard resources for the teaching and learning activities of specific topics (Department of Basic Education, 2011a:15-65). The ATP policy document provides teachers with a specific list of resources (although vague on details) needed for teaching and learning activities of each CAPS topic, as seen in Table 4-43 (Department of Basic Education, 2021c:14-22).



Figure 4-67: Materials for free play inside

Although most of the resources mentioned above are needed in each individual classroom in Life Skills, larger equipment (outdoor play equipment) is shared within schools. Based on observations of cases (classrooms), 9% of the classrooms in the Farm schools, 36,8% of those in the Township schools and 80% of those in the Model C school have toys available in the classroom for open and unstructured play. Of the eight sites, 33.3% of the Farm schools, 50% of the Township schools and the Model C school (i.e. 100%) have outdoor play equipment. A noticeable lack in the availability of equipment and materials at school is seen at the Farm and Township schools.

It is important to note that due to the play-based nature of the Grade R curriculum, the classrooms that are better equipped with equipment and materials for hands-on exploration inside the classroom tend to be Grade R classrooms at all three types of schools.

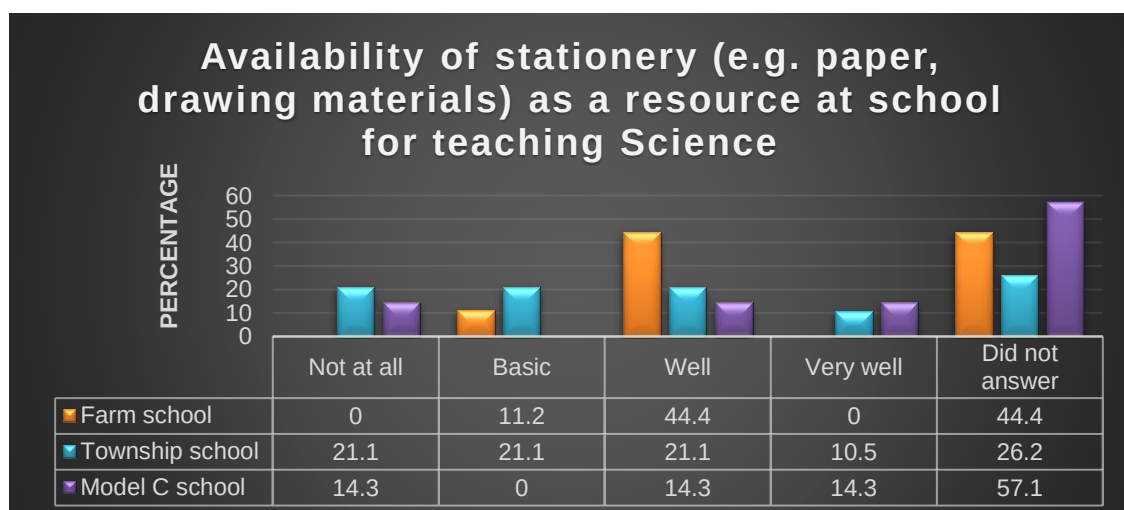


Figure 4-68: Availability of stationery at school for teaching Science

A total of 42.6% of the participating teachers opted not to answer the question. Of the remaining participants, those from Farm schools and the Model C school reported that their schools were well equipped with stationery for teaching Science. The participants from Township schools, however, reported the same percentage for not at all, basic and well (see Figure 4-68).

Apart from the availability of equipment and materials at school, the CAPS policy document prescribes the stationery needed for the teaching and learning activities of Life Skills (integrated subject containing Science content) (Department of Basic Education, 2011a:12-13). The list of stationery includes the following: “dry media - wax crayons, paper, oil pastels, chalk, 2B pencils, felt-tipped pens, charcoal, sand, wet media - paint, ink, dyes, mud, brushes of different sizes, sheets of paper or scrap paper in various sizes and colours, earthenware clay, papier maché, play dough, glue, cardboard strips for glue applicators, scissors and pre-mixed starch (Department of Basic Education, 2011a:12-13).

The Department of Basic Education in South Africa provides public schools with stationery and textbooks. Each province in South Africa can make use of different models to procure materials for schools in the province. Provinces can procure all the materials on behalf of schools, procure on behalf of Section 20 schools or provide funding for Section 21 schools, which would then procure their own materials (Nchabeleng, 2021). Public schools in South Africa are divided into Section 20 and 21 schools. While Section 21 (Quintile 4 and 5) schools are financially self-managed, schools under Section 20 (Quintile 1-3) are financially dependent on the finances provided by the Provincial department of Education (Matlhware & Erasmus, 2015:109).

The model for procuring materials used in each province needs to provide schools with the necessary stationery and textbooks at the end of the previous year. At the start of the academic year in 2022, schools in the Eastern Cape province did not receive any stationery and textbooks. The provincial Department of Education of the Eastern Cape province released a memorandum to schools stating that schools would receive stationery by the end of February (one month into teaching and learning activities) and textbooks between March and May (two to four months into teaching and learning activities). The Department encouraged schools to make use of stationery left over from the previous year. However, the schools indicated that the stationery allocated to the Department of Education in the previous year was far from adequate to meet the needs of the learners (Van Schalkwyk, McConnachie & Kota, 2022). The South African court has declared access to stationery as part of the right to basic education (Van Schalkwyk *et al.*, 2022).



Figure 4-69: Availability of stationery in different classrooms

As seen, the policy documents for Life Skills prescribe the use of different types of stationery as standard for teaching and learning activities in Grade R to 3 (Foundation Phase) (Department of Basic Education, 2011a:12-13). Based on observation, 36.4% of the classrooms at the Farm schools, 42.1% of those at the Township schools and 100% of those at the Model C schools have stationery available in the classroom for learners. There is a clear discrepancy between the availability and needs of teachers and learners and service delivery to schools in South Africa, as seen in the example above. The results of the participants from the different Township schools support this finding.

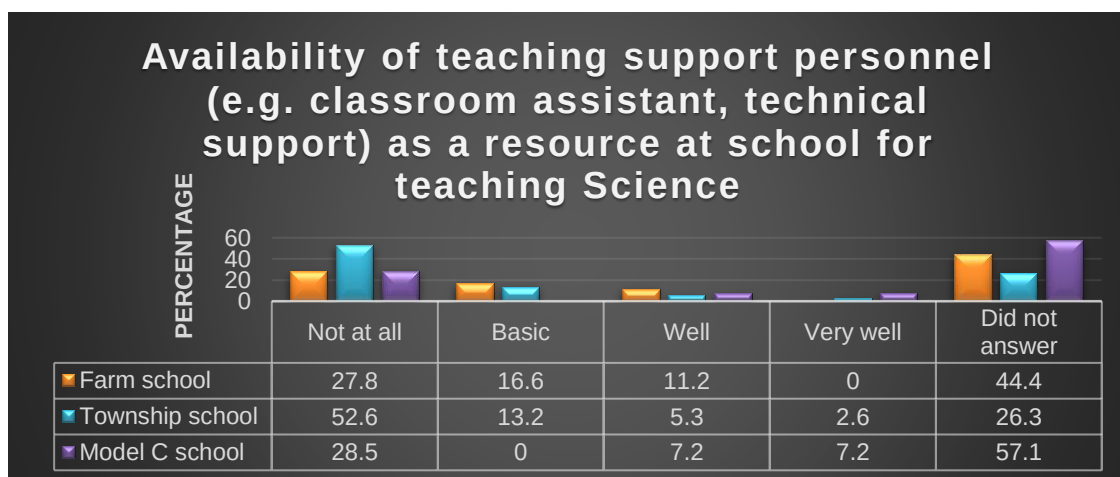


Figure 4-70: Availability of support personnel at school for teaching Science

A total of 42.6% of the participating teachers opted not to answer the question. The remaining participants indicated that there were basic or no teaching support personnel available (see Figure 4-70).

Classroom assistants are not a common practice in South Africa, except for schools that host in-service training for university students for two months of the year. As seen in Table 4-38, only 41.8% of schools have computer centres and thus have no need for technical support if the school does not have such a centre. A further constraint is the funding for support personnel, as funds in Quintile 1 to 3 schools are managed by the Provincial department of Education (Mathwale & Erasmus, 2015:109).

4.7.2 Question 31 of the adapted Creative Little Scientists questionnaire

Question 31 was “How well resourced do you feel your school is for the teaching of **MATHEMATICS** in terms of the following?”. See Table 4-39 below for a breakdown of the sub-questions and the Likert scale.

Table 4-39: Resources available at school to teach Mathematics

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional and library materials (e.g. textbooks and storybooks)				
b. Audio-visual and digital resources				
c. Equipment and materials for hands-on exploration inside and outside of the classroom				
d. Stationery (e.g. paper, drawing materials)				
e. Teaching support personnel (e.g. classroom assistant, technical support)				

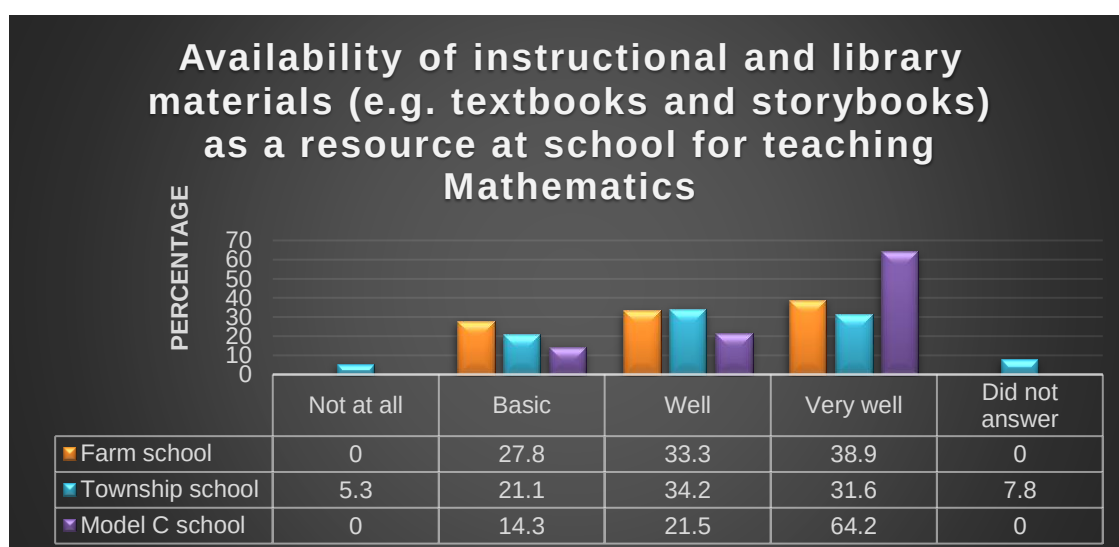


Figure 4-71: Availability of instructional and library materials at school for teaching Mathematics

Of the participating teachers, 2.6% opted not to answer the question. The participants indicated that their schools were well equipped with instructional and library materials. The participants from the Model C school responded that they were very well equipped, more than the other two types of schools (see Figure 4-71).

The CAPS policy document prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities in Mathematics (Department of Basic Education, 2011b:16). Grade R learners are prescribed storybooks and their Department of Basic Education workbooks as library materials. Learners in Grades 1 to 3 are only prescribed their Department of Basic Education workbooks for Mathematics (Department of Basic Education, 2011b:13, 16). Other textbooks that teachers use for the teaching and learning activities of Mathematics are provided by the Provincial Department of Education. The Department of Education has developed 1 100 titles of state-owned content resources, under which fall 344 workbooks for Grades R to 9 and 594 Graded Readers and Big Books for Grades 1 to 3 in all 11 languages (Nchabeleng, 2021).

With regard to the prescribed library materials needed for Life Skills (see Section 4.7.1), the policy documents indicate that fewer types of library materials are required for the teaching and learning activities of Mathematics. The Department of Basic Education provides schools with other textbooks that can be used for teaching and learning activities, and each learner is provided with a Department of Education workbook. From the discussion above, teachers have access to adequate library materials for teaching Mathematics.

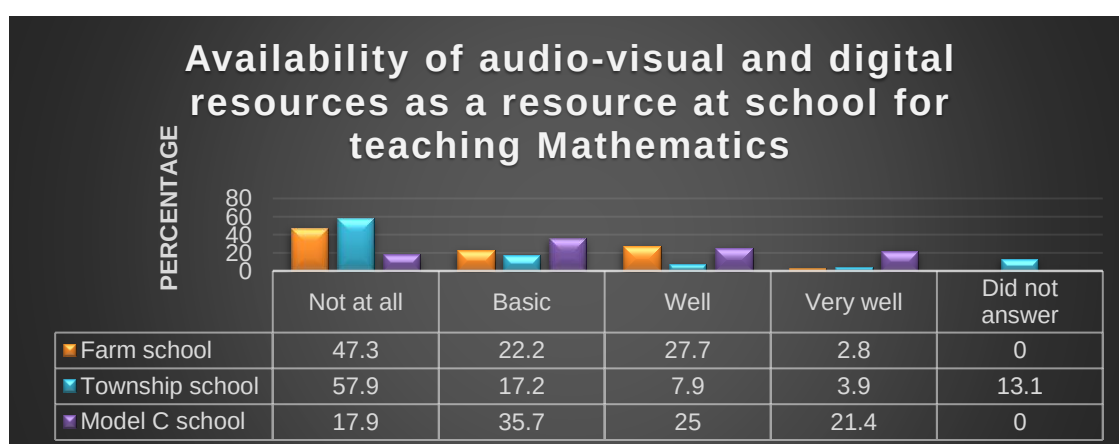


Figure 4-72: Availability of audio-visual and digital resources at school for teaching Mathematics

Of the participating teachers, 4.4% opted not to answer the question. The participants from Farm and Township schools indicated that their schools were basically or not equipped with audio-

visual and digital resources. The majority of the participants from the Model C school indicated that the school was well equipped with audio-visual and digital resources (see Figure 4-72).

The CAPS policy document (Department of Basic Education, 2011b:13) does not prescribe the use of audio-visual and digital resources in the teaching and learning activities of Mathematics. Instead, the focus is on moving learners from the kinaesthetic stage (experience concepts with the body and senses) to the concrete stage (3D, using a variety of different objects) and, lastly, the paper-and-pencil representation stage (Department of Basic Education, 2011b:13).

Although it is not prescribed for learners to have access to audio-visual and digital resources for the teaching and learning activities of Mathematics, the use of audio-visual and digital resources can enhance teaching and learning activities. A variety of educational applications are available for Mathematics, which can be a powerful tool when teaching specific concepts (Durmus & Karakirik, 2006:117). The results from the participants indicate a lack of availability of audio-visual and digital resources at schools. As mentioned above (see Section 4.7.1), although all eight of the sites used for data generation have computer centres, the centres of seven of the sites are not in working order. Two of the eight sites use their computer centres as regular classrooms, with none of the audio-visual and digital resources in these classrooms other than the smartboard (see Figure 4-73 below). The remaining classrooms are equipped with a chalkboard and have no audio-visual and digital resources.



Figure 4-73: Computer centre used as regular classroom

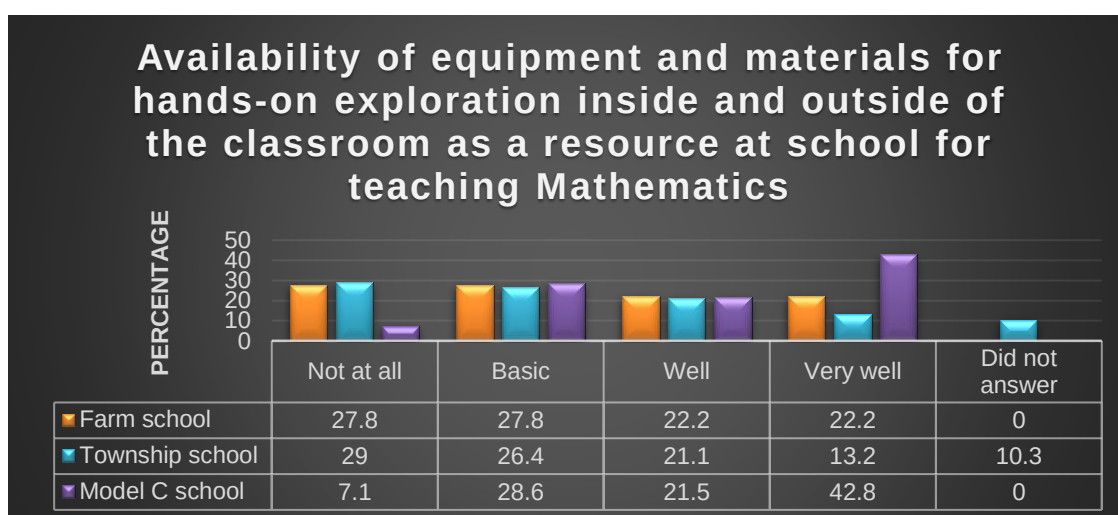


Figure 4-74: Availability of equipment at school for teaching Mathematics

Of the participating teachers, 3.4% opted not to answer the question. The responses of the participants from Farm and Township schools were mostly similar – not at all, basic and well – with higher percentages for not at all and basic. Most of the participants from the Model C school reported that their school was well equipped with equipment and materials for teaching Mathematics (see Figure 4-74).

The CAPS policy document prescribes a play-based learning approach for Grade R learners in Mathematics (Department of Basic Education, 2011b:13). Teachers are encouraged to develop learners' emergent numeracy, which includes "cognitive development (problem-solving, logical thought and reasoning), language development (the language of Mathematics), perceptual-motor development and emotional and social development" (Department of Basic Education, 2011b:13). The policy document prescribes the following activities for Grade R learners: "aspects of numeracy, stories, songs, rhymes, finger games and water play, educational toys including board games, construction and exploration activities (mass, time, capacity, measurement, etc.), imaginative play, outdoor play and playground games" (Department of Basic Education, 2011b:13). Furthermore, the CAPS policy document prescribes the following basic equipment and materials for teaching Mathematics in Grades 1 to 3: "Counters, large dice, a big counting frame, a height chart, big 1-100 and 101-200 number grid posters (100-charts), different number lines (vertical and horizontal), a set of Flard cards (expanding cards), play money — coins and notes, a calendar for the current year, a large analogue wall clock, a balance scale, building blocks, modelling clay, a variety of boxes of different shapes and sizes brought from home, a variety of plastic bottles and containers to describe and compare capacities, good examples of a sphere (ball), a rectangular prism (box), cube, cone, pyramid and cylinder (the teacher can make

this herself), a number of plastic or cardboard squares, different rectangles, circles, different triangles all of different sizes, mathematical games, e.g. Ludo, Snakes and Ladders, Jigsaw Puzzles, Dominoes, Tangrams etc., areas for sand and water play, apparatus for climbing, balancing, swinging and skipping, a play-shop with items to be bought with play-money” (Department of Basic Education, 2011b:16).

Although most of the resources mentioned above are needed in each individual classroom for Mathematics, larger equipment (outdoor play equipment) is shared within schools. As mentioned in Question 30 (see Section 4.7.1), based on the researcher’s observation of the cases (classrooms), 9% of the classrooms of the Farm schools, 36.8% of those of the Township schools and 80% of those of the Model C school have toys available in the classroom for open and unstructured play. Furthermore, 54.5% of the Farm schools, 36.8% of the Township schools and the Model C school (i.e. 100%) have some form of equipment for teaching and learning activities in Mathematics available in the classroom. Of the eight sites, 33.3% of the Farm schools, 50% of the Township schools and the Model C school (i.e. 100%) have outdoor play equipment. A noticeable lack of availability of equipment and materials at school is seen in the Farm and Township schools.

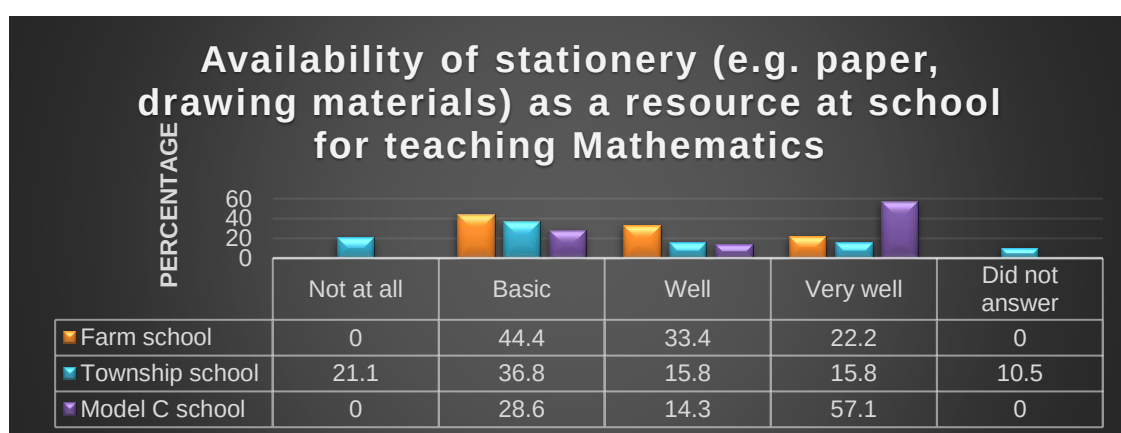


Figure 4-75: Availability of stationery at school for teaching Mathematics

Of the participating teachers, 3.4% opted not to answer the question. Of the remaining participants, those from Farm schools and the Model C school indicated that their schools were well equipped with stationery for teaching Science. However, most of the participants from Township schools indicated that their schools were not at all or basic equipped with stationery (see Figure 4-75).

Although the CAPS policy document for Mathematics prescribes basic equipment and materials for teaching Mathematics in Grades 1 to 3, no mention is made of stationery needed (Department of Basic Education, 2011b:16).

Learners in the Grade R-3 (Foundation Phase), however, do need basic stationery, such as pencils, erasers, rulers, scissors and paper. A noticeable lack in the availability of equipment and materials is seen at the participating Farm and Township schools.

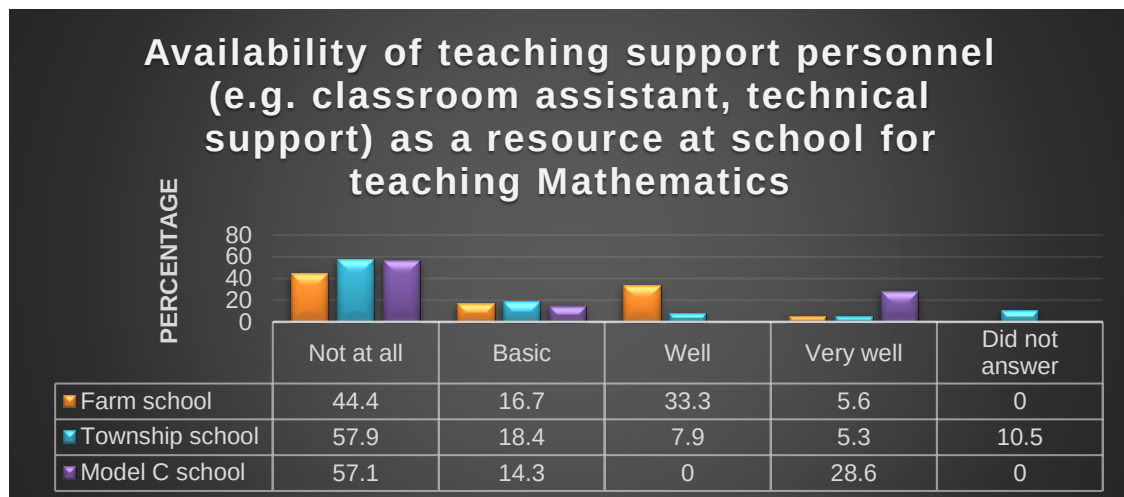


Figure 4-76: Availability of support personnel at school for teaching Mathematics

Of the participating teachers, 3.4% opted not to answer the question. The remaining participants indicated that only basic or no teaching support personnel were available at their schools (see Figure 4-76).

As mentioned under Question 30 (see Section 4.7.1), classroom assistants are not a common practice in South Africa, except for schools that host in-service training for university students for two months of the year. As seen in Table 4-38, only 41.8% of schools in South Africa have computer centres and thus have no need for technical support if the school does not have such a centre.

4.7.3 Question 32 of the adapted Creative Little Scientists questionnaire

Question 32 was “**How often do you use the following resources in your SCIENCE teaching?**”. See Table 4-40 below for a breakdown of the sub-questions and the Likert scale.

Take note that the first scale “never” – refers to the class or school having the resource but never using it. The scale indicating N/A – refers to not applicable because the participant does not have the resource in either their class or school.

Table 4-40: Using resources in Science teaching

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Instructional and library materials (e.g. student textbooks, storybooks and relevant media material)					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. ICT and audio-visual resources					
e. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					

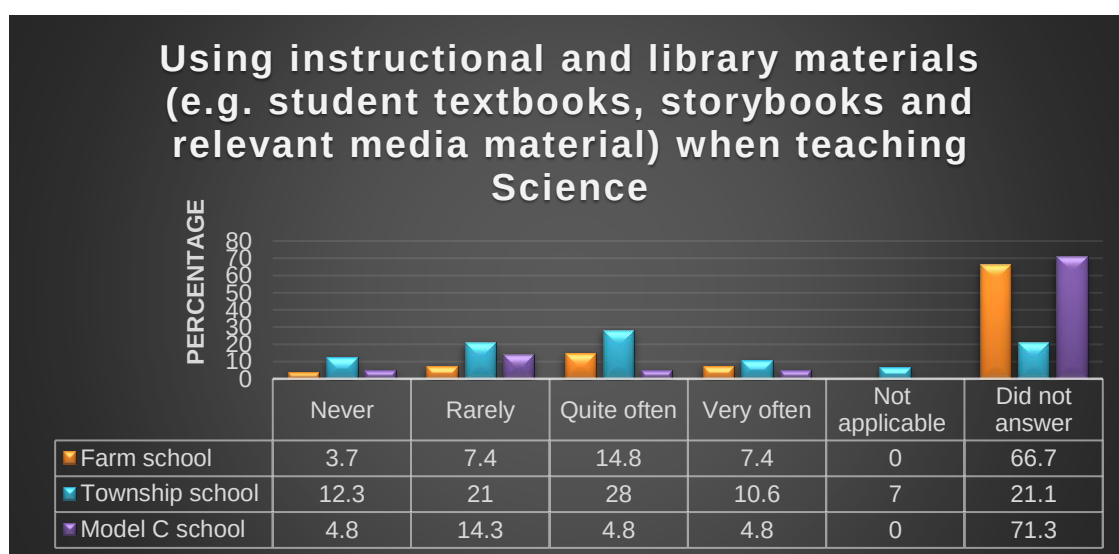


Figure 4-77: Using instructional and library materials when teaching Science

Of the participating teachers, 53% opted not to answer the question. The remaining participants from both Farm and Township schools indicated that they often made use of instructional and library materials when teaching Science. The participants from the Model C school indicated that they rarely made use of instructional and library materials when teaching Science (see Figure 4-77).

The integrated nature of the Life Skills (integrated subject containing Science content) subject prescribes that teachers incorporate a CAPS topic into all four of the learning areas (Department of Basic Education, 2011a:12). For example, learners will engage in Beginning Knowledge activities such as learning the characteristics of insects, while in Creative Arts, they will draw and paint insects along with stories and rhymes, and in Physical Education, they will walk like insects (Department of Basic Education, 2021c:11-22). This document provides teachers with a list of resources that will be needed for teaching and learning activities of specific topics. These resources include library or information books, pictures, flashcards, charts, posters and maps under Beginning Knowledge and Creative Arts activities (Department of Basic Education, 2011a:15-65). The ATP policy document indicates the corresponding page numbers in the Department of Basic Education workbook of each activity that supports the teaching and learning activities of the CAPS topic of the particular week, as seen in Table 4-43 (Department of Basic Education, 2021c:14-22).

As seen above, the use of instructional and library materials when teaching Science is frequently prescribed in Life Skills and is supported by the results from the participants.

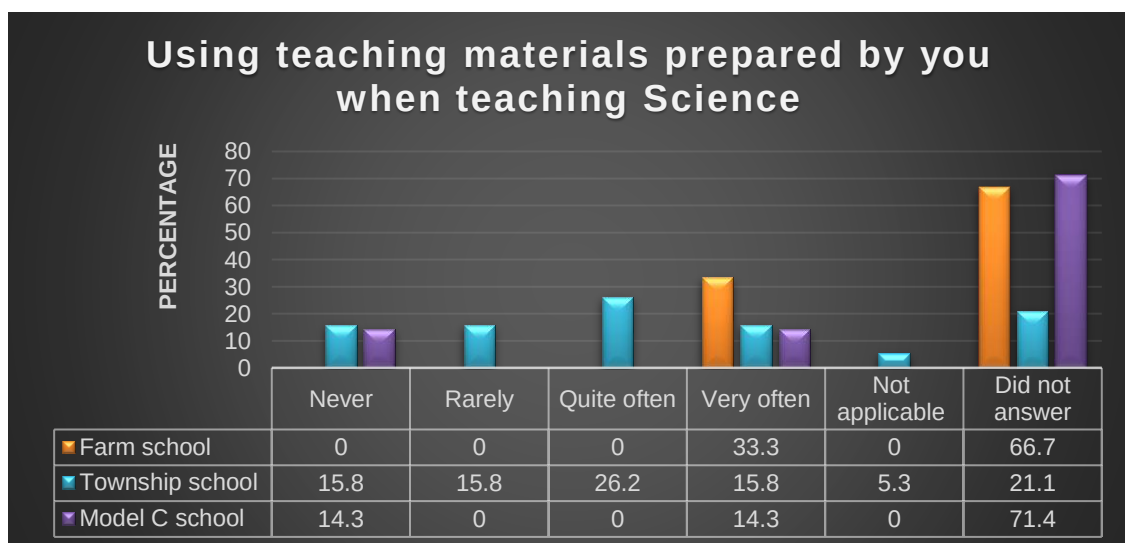


Figure 4-78: Using teaching materials prepared by the teacher when teaching Science

A total of 53% of the participating teachers opted not to answer the question. The remaining participants from both Farm and Township schools indicated that they often made use of teaching materials prepared by themselves when teaching Science. The participants from the Model C school responded with the same percentage for never and very often making use of teaching materials prepared by themselves when teaching Science (see Figure 4-78).

The CAPS policy document (Department of Basic Education, 2011a:12) prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities of Life Skills (integrated subject containing Science content) (Department of Basic Education, 2011a:12). Although the list mostly prescribes resources that need to be purchased or collected (e.g. recyclable materials) for exploration inside and outside the classroom, there are some materials that can be made by teachers, such as puppets, puzzles and other manipulative educational toys and visual stimuli for drawing and construction (Department of Basic Education, 2011a:12-13).

As seen in the policy document, teachers make use of the Department of Basic Education workbooks provided by the Department of Education. The policy document furthermore prescribes various resources – purchased or made by teachers – for the teaching and learning activities of Life Skills (Department of Basic Education, 2011a:12-13).

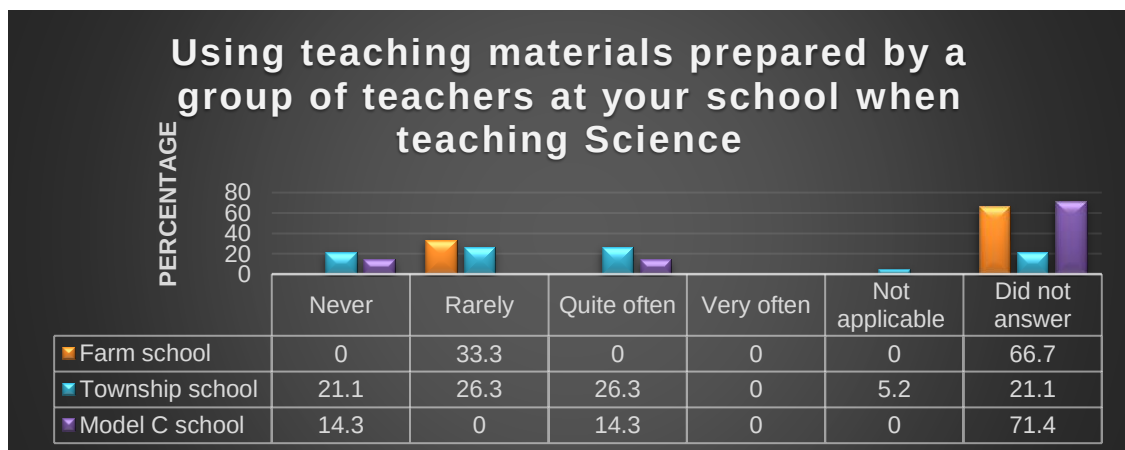


Figure 4-79: Using teaching materials prepared by a group of teachers when teaching Science

Of the participating teachers, 53% opted not to answer the question. The remaining participants from both Farm and Township schools indicated that they rarely or never made use of teaching materials prepared by a group of teachers at their schools when teaching Science. The participants from the Model C school responded with the same percentage for never and quite often making use of teaching materials prepared by a group of teachers at their school when teaching Science (see Figure 4-79).

As seen in the previous discussion, most of the prescribed resources for Life Skills (integrated subject containing Science content) need to be purchased or collected in the form of recyclable materials for exploration inside and outside the classroom. Some materials can be made by

teachers, for example puppets, puzzles and other manipulative educational toys and visual stimuli for drawing and construction (Department of Basic Education, 2011a:12-13).

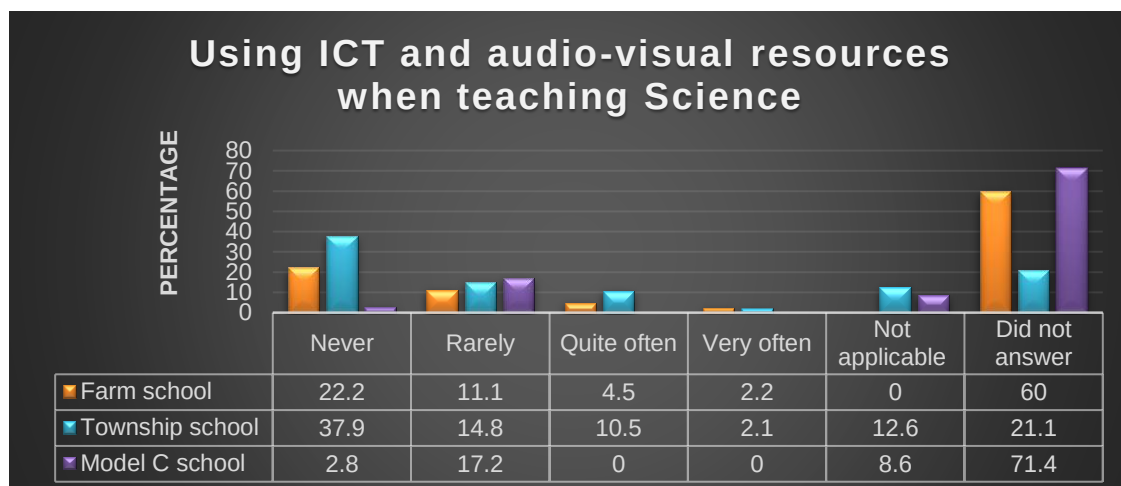


Figure 4-80: Using ICT and audio-visual resources when teaching Science

Of the participating teachers, 51.2% opted not to answer the question. The remaining participants indicated that they never or rarely made use of ICT and audio-visual resources when teaching Science.

The policy documents for Life Skills (integrated subject containing Science content) do not prescribe or require teachers to use computers, computer applications or interactive whiteboards and cameras for teaching and learning activities. This is supported by the data from the participants indicating that they never or rarely make use of ICT and audio-visual resources when teaching Science.

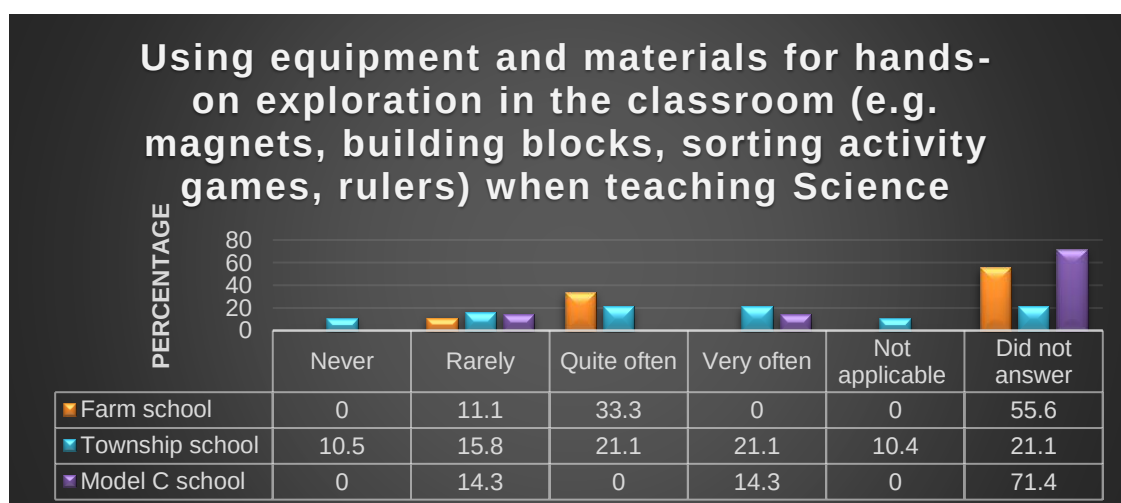


Figure 4-81: Using hands-on equipment and materials when teaching Science

A total of 49.4% of the participating teachers opted not to answer the question. The remaining participants from both Farm and Township schools indicated that they often made use of hands-on equipment and materials when teaching Science. The participants from the Model C school responded with the same percentage for rarely and very often making use of hands-on equipment and material when teaching Science (see Figure 4-81).

As mentioned before (see Section 4.7.1), the CAPS policy document for Life Skills (integrated subject containing Science content) prescribes a list of a wide range of standard resources that schools or teachers should have available for the teaching and learning activities of Life Skills (Department of Basic Education, 2011a:12).

The ATP policy document provides teachers with a specific list of resources (although vague on details) needed for the teaching and learning activities of each CAPS topic, as seen in Table 4-43 (Department of Basic Education, 2021c:14-22).

Figures 4-82 and 4-83 below show examples of lesson plans for Life Skills. The teachers indicate how the CAPS topic is integrated into the four learning areas and what hands-on equipment and materials will be used. Figure 4-82 indicates the use of samples of different types of soil, pictures, puppets, pastel crayons and ink needed for the teaching and learning activities under the topic of soil. Figure 4-83 indicates that the learners will pick up trash at their school as part of the activities under the topic of pollution and use mixed media in the Creative Arts section.

LIFE SKILLS Grade 2: 6 hours - 360 minutes per week				
Term 3: Week 1 - Grade 2				Educator:
Beginning Knowledge:	MONDAY (30 min)	TUESDAY (30 min)	WEDNESDAY (30 min)	THURSDAY (30 min)
	Topic: Soil - Why is land important? - Discuss different types of soil - colour and texture. - sand Land - Clay ground - loam	Topic: Soil - Find out what sort of soil is at your school. - Bring soil from three different places in cans to school and discuss. - Discussion: - How does it feel? - How does it look? - Are there plants growing the soil?	Topic: Soil Study different pictures and talk about the animals that live holes in the soil, eg. Earthworms, moles, rabbits, field mice, etc.	Topic: Soil - Discuss the concept of Texture. - Texture means how something feels eg. hard, rough, soft, moist, etc. - Study pictures and discuss each object's texture.
Personal & Social Well-being:				
Creative Arts:	WEDNESDAY (40 min)		FRIDAY (75 min)	
	Improvise and interpretation Creating a simple puppet using waste material, sock puppets, finger puppets, shadow puppets		Create in 2-D - Make paintings or drawings of birds, fish, insects, reptiles, etc. use oil pastels in warm colors and wash into inks or cool colors. Discuss color, shape, texture, pattern and specialization; look at and discuss famous artworks or natural world. - Collect nature objects eg. leaves, twigs, wool etc. to decorate your picture.	
Physical Education:	MONDAY (40 min)	TUESDAY (40 min)	THURSDAY (40 min)	
	Functional movement: Locomotion Warming up: - Game: Follow the leader Main activity: - Marching on the spot and bounce a ball - Bounce a ball against the wall Cooling - Make a circle, breathe in, breathe out - Reflection	Sport - Mini - netball - Rugby	Locomotor - Obstacle course with bean bag on hand / shoulder / foot / head - Reaction time drills, ie at the teacher's command ... run ... hit the deck ... hop ... stop ... etc.	
Lesson Planning: Life Skills Grade 2 Term 3				
www.myklakamer.co.za				

Lesson Planning: Life Skills Grade 2 Term 3

www.myklaskamer.co.za

Figure 4-82: Life Skills lesson plan Grade 2

LIFE SKILLS				
GRADE 3 - TERM 3: WEEK 3				
Beginning Knowledge: • Social Sciences • Natural sciences • Technology Personal & Social Well-being: • Social Health	MONDAY (45 min) Pollution • Scetch a "scenario" for children to introduce a concept of pollution. E.g. Ben lives in a rural area and walks 3km to school every day. He walks past a stream next to a large factory every day. One day, Ben was very thirsty and drank water from the stream. However, he became very ill. Why do you think Ben got sick? What could have caused his illness?	TUESDAY (45 min) Pollution • Revision: What is pollution. • Look at different pictures that depict pollution and identify the pollution in each picture. • Keep a clean-up session. Go to your playground and see how much litter lies around. Pick up and throw in garbage bag. • Now list all the types of trash you have found on the school grounds.	WEDNESDAY (45 min) Pollution • Different types of pollution: Water pollution. • Let's talk about water pollution. • How is water contaminated? • What do you think are the consequences if a water source is polluted by eg. A plant that has poisonous substances in it? • What is sewage and do you think it is safe?	FRIDAY (45 min) Pollution • Different types of pollution: soil pollution. • What is soil pollution? • Why do you think soil pollution is bad and who is being affected by soil pollution? • What are chemicals and why is it dangerous?
	Creative arts: • Visual Arts • Performing Arts	WEDNESDAY (40 min) Improvise and Interpret • Warming up voice: focus on expressiveness and involvement in poetry, rhymes and creative drama games		FRIDAY (80 min) Create in 2-D • Drawing and painting: exploring a variety of media • Design principles: conscious application and naming of contrast, proportion, emphasis and balance • Draw a nature picture. Paste garbage on the picture to the effect illustrates pollution.
Physical Education: • Perceptual development • Coordination	TUESDAY (60 min) Rhythm • Rope skipping - advanced movement such as cross over, double skip, etc. • Gymnastic movement such as forward roll, backward roll, hand spring, and cartwheel		THURSDAY (60 min) Sports and Games • Rugby • Netball • Ballskills	

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www.myklaskamer.co.za [2018]

Figure 4-83: Life Skills lesson plan Grade 3

As seen in the discussion of the policy documents, the use of equipment and materials for hands-on exploration in the classroom is prescribed on a daily or weekly basis.

4.7.4 Question 33 of the adapted Creative Little Scientists questionnaire

Question 33 was “**How often do you use the following resources in your MATHEMATICS teaching?**”. See Table 4-41 below for a breakdown of the sub-questions and the Likert scale.

Take note that the first scale “never” – refers to the class or school having the resource but never using it. The scale indicating N/A – refers to not applicable because the participant does not have the resource in either their class or school.

Table 4-41: Using resources in Mathematic teaching

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Instructional and library materials (e.g. student textbooks, storybooks and relevant media material)					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. ICT and audio-visual resources					
e. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					

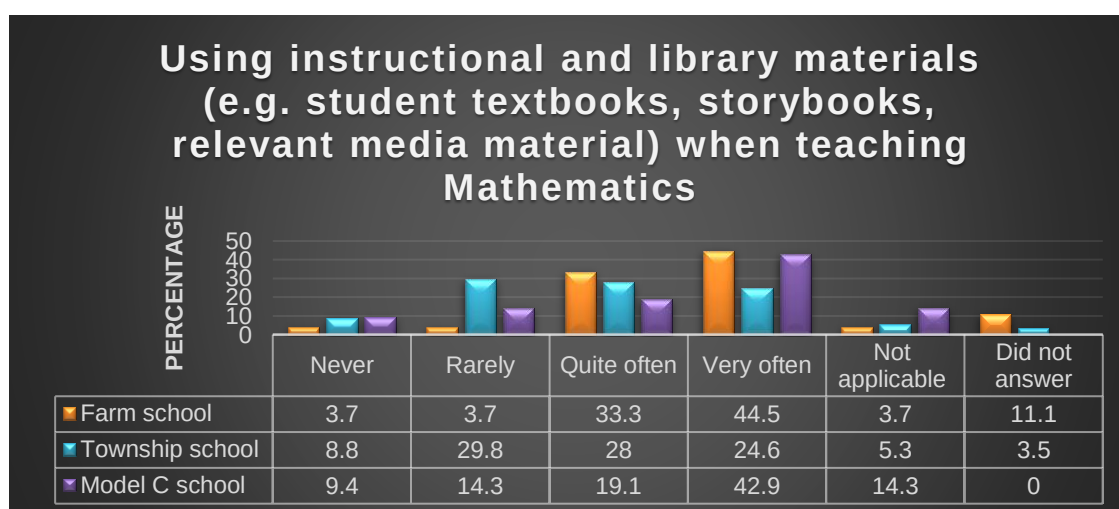


Figure 4-84: Using instructional and library material when teaching Mathematics

Of the participating teachers, 4.9% opted to not answer the question. The remaining participants indicated that they often made use of instructional and library materials when teaching Mathematics (see Figure 4-84).

As mentioned in the discussion of Question 31 (see Section 4.7.2), the CAPS policy document prescribes a list of standard resources that schools or teachers should have available for the teaching and learning activities in Mathematics (Department of Basic Education, 2011b:16). Although storybooks are prescribed for learners in Grade R, learners in Grades 1 to 3 are prescribed their Department of Basic Education workbooks (Department of Basic Education, 2011b:13, 16).

As seen above in the policy documents, storybooks and other relevant media materials required for the teaching and learning activities of Mathematics are much fewer than for the Life Skills in Grade R to 3 (Foundation Phase). The ATP policy document provides teachers with guidelines by indicating the CAPS topic for each week and giving the relevant page number of the Department of Education workbooks (see Table 4-46) under each (Department of Basic Education, 2021a:2). As storybooks and other relevant media materials are only prescribed for Grade R learners, teachers have access to adequate library materials used often for teaching Mathematics, as textbooks or workbooks are provided to each school by the Provincial Department of Education.

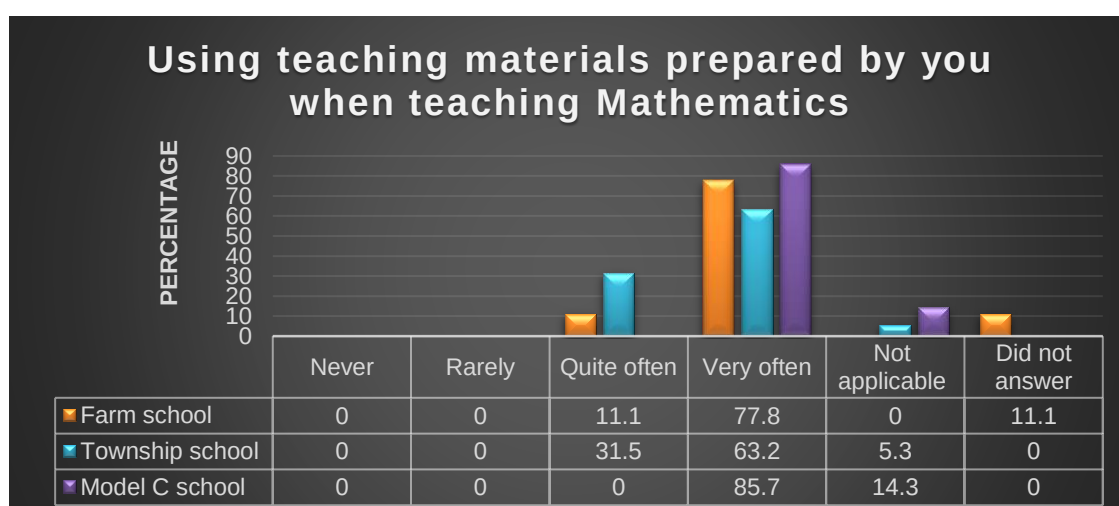


Figure 4-85: Using teaching materials prepared by the teacher when teaching Mathematics

Of the participating teachers, 3.7% opted not to answer the question. The remaining participants indicated that they very often made use of teaching material made by themselves when teaching Mathematics (see Figure 4-85).

From the participating sites, teaching materials made by the teachers were often observed on the maps of the space (classroom). For making teaching material, however, a large amount of time, stationery and materials is needed, while schools often have no budget for the latter. Large numbers of learners per classroom also contribute to the cost of materials, as manipulatives need to be recreated 30 to 50 times. Teachers are often forced to make their own materials, as it is difficult to find materials in all 11 official South African languages. Figure 4-86 below shows an example of number names in Setswana made by a teacher. Also seen in the example is a clock that can be manipulated made by the teacher for teaching the concept of time.



Figure 4-86: Mathematics materials made by teachers

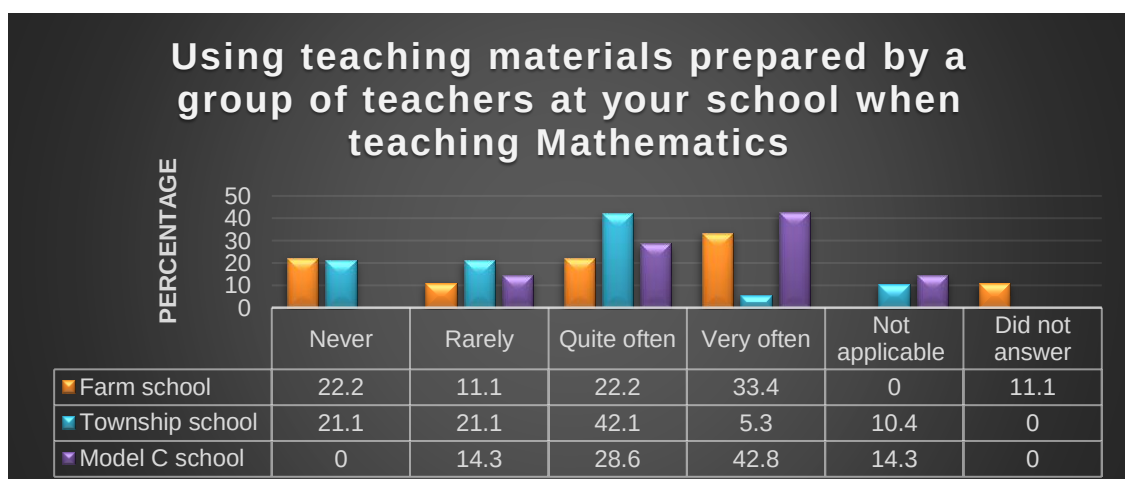


Figure 4-87: Using teaching materials prepared by a group of teachers when teaching Mathematics

Of the participating teachers, 3.7% opted not to answer the question. The remaining participants indicated that they often made use of teaching materials prepared by a group of teachers at their schools when teaching Mathematics. The participants from Township schools indicated that they less often made use of teaching materials prepared by a group of teachers at their school than the participants from the other schools.

The CAPS policy document prescribes activities for Grade R learners that include the use of various materials and types of equipment (Department of Basic Education, 2011b:13). For Grades 1 to 3, the policy document also provides a list of equipment and materials to be used when teaching Mathematics content. The document references that teachers can make some of the prescribed materials and equipment themselves (Department of Basic Education, 2011b:16).

Taking into consideration the large amount of equipment and materials needed for the teaching and learning activities of Mathematics, the participating teachers confirmed that they often used materials prepared by a group of teachers at their schools.

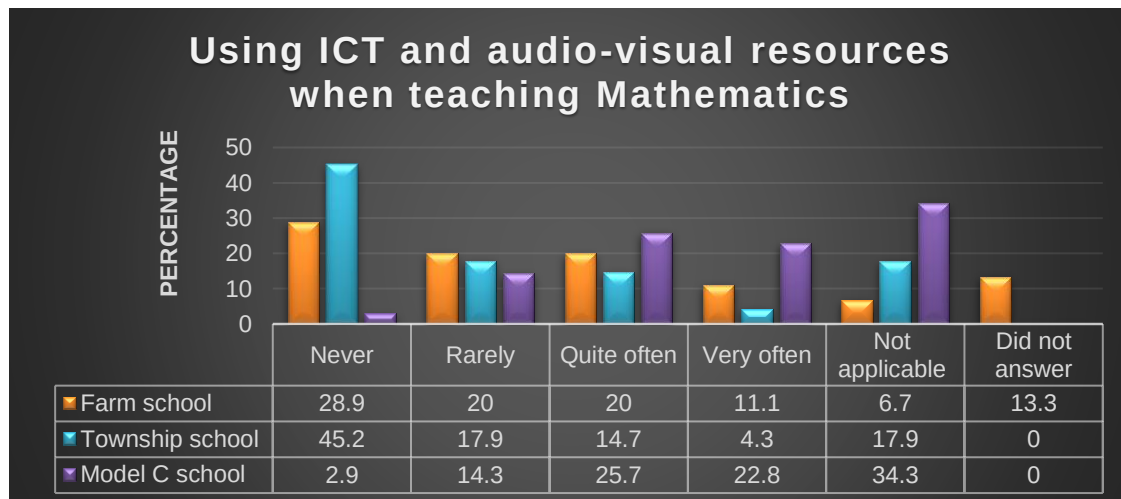


Figure 4-88: Using ICT and audio-visual resources when teaching Mathematics

Of the participating teachers, 4.4% opted not to answer the question. The participants from Farm and Township schools indicated that they never or rarely made use of ICT and audio-visual resources when teaching Mathematics. The majority of the participants from the Model C school indicated that they often made use of ICT and audio-visual resources when teaching Mathematics, but in conflict with this, a large number of these participants also responded with

not applicable because they do not have the resource in the classroom or at school (see Figure 4-88).

The policy documents do not specifically prescribe the use of audio-visual and digital resources in the teaching and learning activities of Mathematics. As mentioned above (see Section 4.7.2), the focus is instead on moving learners from the kinaesthetic stage (experience concepts with the body and senses) to the concrete stage (3D, using a variety of different objects) and, lastly, the paper-and-pencil representation stage (Department of Basic Education, 2011b:13).

A variety of educational applications are available for Mathematics, which can be a powerful tool when teaching specific concepts. Applications can be used to simplify and model content and context to learners that allow them to explore Mathematics content that would otherwise not be possible (Durmus & Karakirik, 2006:118). The lack of access to and availability of computer centres and internet connectivity (see Tables 4-38 and 4-44) has an impact on the use of educational application resources, as supported by the results from the participants.

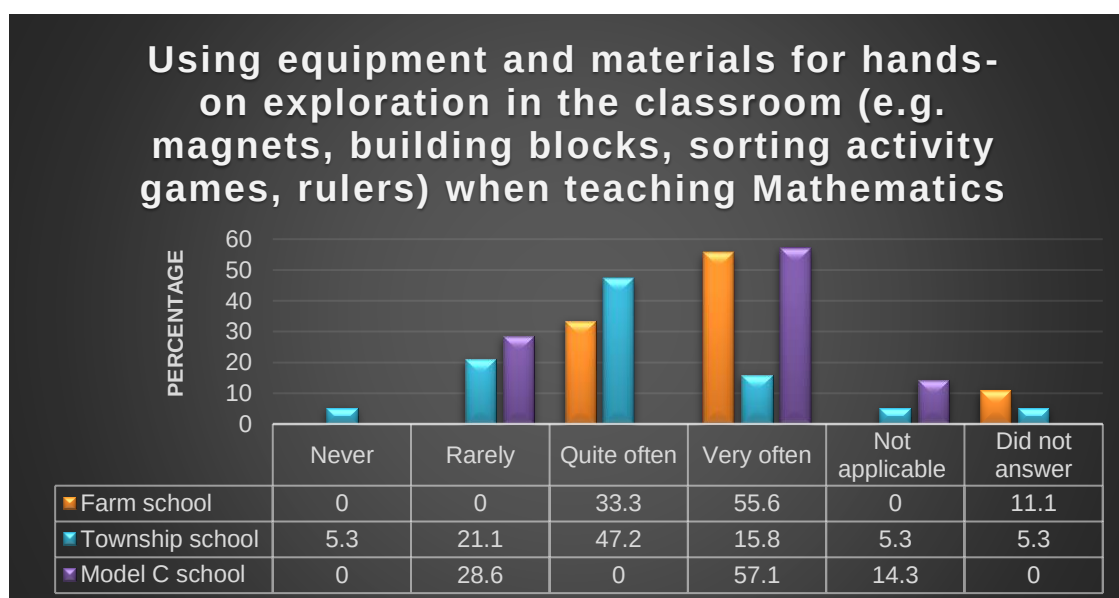


Figure 4-89: Using hands-on equipment when teaching Mathematics

A total of 5.5% of the participating teachers opted not to answer the question. The remaining participants indicated that they often made use of hands-on equipment and materials when teaching Mathematics. The participants from Township schools indicated that they less often made use of hands-on equipment at their schools than the participants from the other schools (see Figure 4-89).

The CAPS policy document provides teachers with a list of standard equipment that is needed for teaching and learning activities in Mathematics (Department of Basic Education, 2011b:16).

The ATP policy document provides teachers with specific materials and equipment that are needed each week when dealing with a specific CAPS topic, as seen below in Table 4-46.

From the observations of the lesson plans, the participants make use of manipulatives when planning for teaching and learning activities, as seen in Figure 4-90 below

MATHEMATICS		GRADE 2 TERM I MATHEMATICS TEACHER:		
Day	1	WEEK 4	THURSDAY	NOTES
Grade	3	Complete number patterns by counting on/back.		
Content	Number Operations and Relationships	Whole Class: Mental Math (10 min)	WORD PROBLEM: SHARING	
Topic	Place Value	Problem Solving (10 min)	Word problems in context by sharing that include remainders. Writing: draw a picture; use a number line; write a number sentence.	
	-Give learners base ten blocks -Ask learners to show everything that tells them more about units. -Ask them what are the differences between units,tens and hundreds -Write the number on the board e.g 785 -Learners say the number -Teacher show the number on the flashcard -Learners show the number with the base ten block -Teacher draw the number line on the board:	Whole Class: NUMBER CONCEPT DEVELOPMENT (10 min)	PLACE VALUE TU Decompose $34 = 30 + 4$ Use blocks and count how many tens + units write a number sentence e.g. $1T + 3U = 13$ Write numbers in expanded notation e.g. $15 = 1T + 5U = 10 + 5$	
	-Learners show the number with the base ten block -Teacher draw the number line on the board:	Whole Class: NEW CONCEPTS & REVIEW (15 min)	MEASUREMENT: TIME Introduce Hour pointer 1 hour = 60 minutes The hour hand is short and moves slowly. The hour hand indicates the hour. Reading time in hours e.g. 2 o'clock; 4 o'clock, 5 o'clock, etc. Use time flash cards	
Counting (5 minutes)	Number Range 0-180 Ask learners to count in fives,backwards and forwards -Ask learners questions. -Which number is less than ____ - Which number is more than ____	Group work: REVIEW CONCEPTS (10 min)	TENS & UNITS Revise: Place Value e.g. $13 = \text{units and } 13 = \text{tens}$ Place value means at whose location is the symbol? Use counters to build numbers by grouping in tens and units. $45 = 4T + 5U$	
Mental Mathematics(10 minutes)	Number range: 0-20 (whole class) Rapid recall -Addition and subtraction facts to 20 - $17-3+6=$ $19-1+0=$	Independent (30 min)	Individual Written Task / DBE Books Math Term I Activity Book	
		ASSESSMENT ACTIVITIES ENRICHMENT & INTERVENTION		

Figure 4-90: Lesson plans with material for teaching and learning activities in Mathematics

As seen in the example of a lesson plan for Mathematics and prescribed policy, teachers are encouraged to often make use of hands-on equipment and materials. Where schools have more equipment and materials available, teachers tend to incorporate these in their lessons more frequently.

4.7.5 Question 34 of the adapted Creative Little Scientists questionnaire

Question 34 was “**How often do you consult the following resources to inform your SCIENCE teaching preparation?**”. See Table 4-42 below for a breakdown of the sub-questions and the Likert scale.

Take note that the first scale “never” – refers to the class or school having the resource but never using it. The scale indicating N/A – refers to not applicable because the participant does not have the resource in either their class or school.

Table 4-42: Resources used to inform Science teaching preparation

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Textbooks					
b. Policy documents (school and national)					
c. Education agency websites					

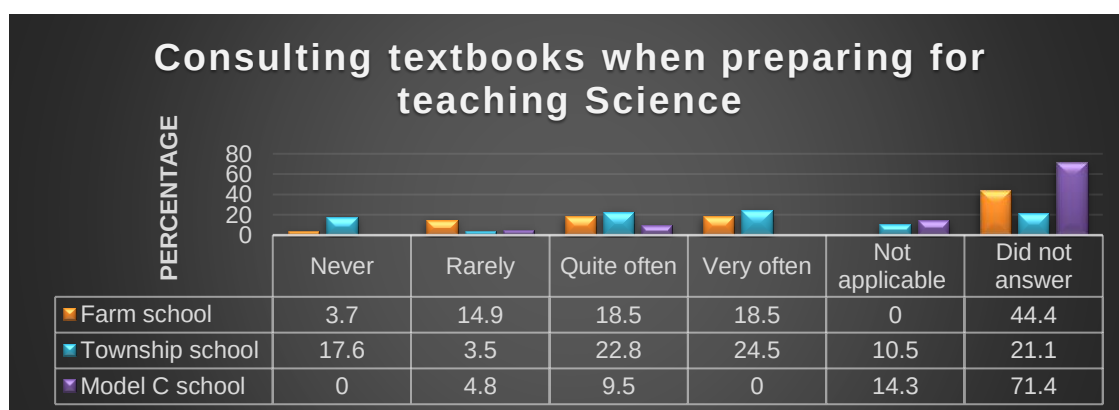


Figure 4-91: Consulting textbooks in preparing for Science teaching

A total of 45.6% of the participating teachers opted not to answer this question. The majority of the remaining participants from Farm and Township schools indicated that they often made use of textbooks when preparing to teach Science. The majority of the participants from the Model C school, in contrast to this, indicated that using textbooks for preparing to teach Science was not applicable (see Figure 4-91).

The ATP provides teachers with a list of types of resources to consult when preparing for a specific CAPS topic (Department of Basic Education, 2021c:11-22). Although the majority of the

participating teachers make use of multiple types of books, a group of the participants does not make use of textbooks to prepare for teaching Science.

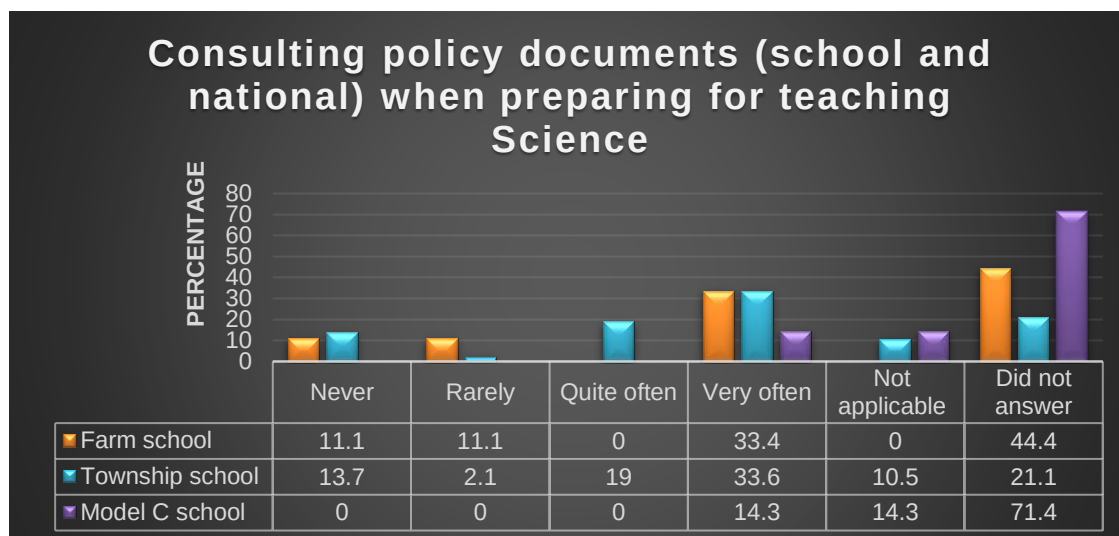


Figure 4-92: Consulting policy documents in preparing for Science teaching

A total of 45.6% of the participating teachers opted not to answer this question. The majority of the remaining participants indicated that they very often consulted policy documents in preparing to teach Science (see Figure 4-92).

The ATP provides teachers in each Grade with a detailed breakdown of the weeks of each term with the CAPS topic, core concepts, skills and values, strategies of teaching, required pre-knowledge, a list of resources and the informal and formal assessment needed for the teaching and learning activities in that week (Department of Basic Education, 2021c:11-22). Table 4-43 below provides an example of the structure provided in the ATP for Life Skills (integrated subject containing Science content). In Table 4-43 below, it can be seen that the ATP policy document for Life Skills integrates the four learning areas, namely Personal and Social Well-being, Beginning Knowledge, Creative Arts and Physical Education, under each CAPS topic where possible (Department of Basic Education, 2021c:11-22).

Although the participants indicated that they often made use of policy documents to prepare for the teaching and learning activities in Science, the table below shows that Science (Beginning Knowledge) topics are integrated into all the learning areas of Life Skills but represented rather vaguely. An example of this statement is seen under the section of Creative Arts where there is an “x” that marks that the activity must be included under the CAPS topic, but no further example or description is provided.

Table 4-43: Extract from the Annual Teaching Plan for Life Skills (Department of Basic Education, 2021c:14-22)

Annual teaching plan extract: Grade 3, term 2, Life Skills			
		Week 6	Week 7
CAPS Topic		Healthy living	Insects
Personal and Social Well-being	SKILLS AND VALUES: • Compare • Observe • Communicate • Identify/ Identity • Ability to ... • Respect • Tolerance etc.	• Food groups • A balanced diet	No natural links to Personal and Social Well-being
	CORE CONCEPTS & KNOWLEDGE REMEMBER to always be aware of activities to promote EXECUTIVE FUNCTION - Working memory Inhibitory control Self-regulation	Life and Living How do we make cheese? Where does bread come from? Energy makes us move and work We need food to give us energy	No natural links to Personal and Social Well-being
	CONTENT: CAPS ENSURE OPTIMAL USE OF DBE WORKBOOKS Reading for meaning (comprehension) of fictional and non-fictional text	• Food groups - Proteins - eggs, beans, meat, nuts - Dairy - milk, cheese, yoghurt • A balanced diet	No natural links to Personal and Social Well-being
	RESOURCES: Flashcards/ Vocabulary for Focus board and Word Wall Library books	• DBE Workbook: 34-41 • 3D • Charts	No natural links to Personal and Social Well-being
	RELIGIOUS AND OTHER SPECIAL DAYS CELEBRATED BY THE COMMUNITY SHOULD BE DISCUSSED AS THEY OCCUR THROUGHOUT THE TERM		
	INFORMAL ASSESSMENT	• The activities must be observed and assessed during daily lesson activities in Life Skills. Also note SKAVs that is developed and mastered for Home Language and Mathematics. • Written activities can be given. • Skills, knowledge application, attitude and values are not meant to be an assessment activity but rather should ensure that learners are afforded opportunities to demonstrate these skills orally, practically and in written form. • This must be done informally and ongoing.	
	SCHOOL BASED ASSESSMENT:	REFER TO DBE SBA Guidelines	
Beginning Knowledge	SKILLS AND VALUES: e.g. • Observe • Compare • Conservation • Measure • Cause & Effect • Communicate • Values, Care etc.	• Investigate "Find out" • Process • Communicate	• Inquiry • Observing • Comparing • Classifying
	REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation Learner talk, discussion, exploration, INQUIRY "find-out", problem solving, thinking and reasoning is of utmost importance.		

Annual teaching plan extract: Grade 3, term 2, Life Skills			
		Week 6	Week 7
CAPS Topic		Healthy living	Insects
	KNOWLEDGE: Conceptual Key points	• How to make cheese • Understand processes	• Life and Living • Types of insect • Movement • Body parts • Characteristics • Usefulness • Harm
	CONTENT: CAPS ENSURE OPTIMAL USE OF DBE WORKBOOKS	• How to make cheese https://youtu.be/gRagqbCIK9c	• Characteristics of an insect: • The body • Different insects – such as a fly • How do insects help us? • How do some insects harm us?
	Reading for meaning (comprehension) of fictional and non-fictional text		
	RESOURCES: Flashcards/ Vocabulary for Focus board and Word Wall Library books		• DBE WB 1 pg.42 – 46 • 3D • Make a pet Motel
	WEATHER: WEATHER TO BE TAUGHT UNTIL LEARNERS CAN INDEPENDENTLY OBSERVE THE WEATHER AND CHANGE THE ICONS DAILY. THE WEATHER CHART SHOULD BE UPDATED DAILY THROUGHOUT THE YEAR. • Predictions • Minimum and maximum temperature • Symbols (Celsius, weather forecast) • Cloud cover • Complete own weather chart - Precipitation (rain), wind, etc. Complete own weather chart. Precipitation (rain), wind, etc. Develop knowledge and skills progressively.		
	INFORMAL ASSESSMENT:	• The practical activities must be observed and informally assessed during daily lesson activities in Life Skills. Also note SKAVs that is developing, developed and mastered for Home Language and Mathematics • Some written activities can be given. • Skills, knowledge application, attitude and values are not meant to be an assessment activity but ensure that learners are afforded opportunities to demonstrate these skills orally and practically. • This is informal and ongoing	
	SCHOOL BASED ASSESSMENT:	REFER TO DBE SBA Guidelines	
Creative arts	CREATE IN 2D Learners to EACH have their own ice cream container with their own stationery (pritt, scissors, pencil crayons, crayons etc.)		
	Formal teaching of drawing and painting etc. exploring a variety of media		x
	Similar to previous term; include emphasis on greater awareness of the body in motion; overlapping.		x
	CREATE IN 3D (BOX SCULPTURES)		

Annual teaching plan extract: Grade 3, term 2, Life Skills			
CAPS Topic		Week 6	Week 7
		Healthy living	Insects
	Teach and extend simple construction techniques to create box sculpture: stacking, joining, surface decoration		
	Spatial awareness: same as before: extend conscious awareness of working in space	x	
	VISUAL LITERACY		
	Use of art elements and design principles in description and discussion; introduce balance		x
	Use artworks and visual stimuli to relate to own work		
	Description of own artwork: use art vocabulary consciously		x
	CREATIVE GAMES AND SKILLS		
	Own space at chair – Teacher to be aware of learners – If activity is not suited for some learners do another activity e.g. develop core strength using chair routines		
	Warming up: focus on posture, alignment of knees over the middle toes when bending and pointing feet	x	
	Warming up: focus on articulation and vocal tone using rhymes, songs, creative games and tongue twisters.		x
	Rhythm games: listening skills, recall contrasting rhythm patterns, keep a steady beat, use different timbres		x
	Developing control, co-ordination, balance and elevation in jumping actions with soft landings (At tables – watch learners balance and core strength)		
	Locomotor and non-locomotor movements with coordinated arm	x	

Annual teaching plan extract: Grade 3, term 2, Life Skills			
		Week 6	Week 7
CAPS Topic		Healthy living	Insects
	movements in time to music		
	IMPROVISE AND INTERPRET (to be covered throughout the term) Use own space at their chair – You may add activities if learners are adapting well to social distancing		
	Interpret and rehearse South African songs: rounds, call and response.		x
	Movement sentence showing beginning, middle and end on a selected topic working in small group – Alternate with PE	x	
	INFORMAL ASSESSMENT:	• The activities must be observed and assessed during daily lesson activities in Life Skills. Also note SKAVs that is developed and mastered for Home Language and Mathematics • Ensure that learners are afforded opportunities to demonstrate these skills practically. • This must be done informally and ongoing.	
	SCHOOL BASED ASSESSMENT:	REFER TO DBE SBA Guidelines	
Physical Education	SKILLS: REMEMBER to always be aware of activities to promote Executive Functioning: Working memory, Inhibitory control and Self-regulation	PLAY IS THE NATURAL WAY LEARNERS LEARN AT THIS AGE AND STAGE OF DEVELOPMENT. PLAY SHOULD NOT BE WITHHELD. • Maintain social distancing. • Activities has been modified to maintain social distancing. • The activities are adapted for a classroom situation- where overcrowding exist- allow learners to be keep a safe distance outside the class. • Locomotor activities can be practiced whilst learners are walking in and out of class in the morning or returning from interval. • Navigating safely when responding to movement instructions • Ensure that the lessons have the following activities: warm-up, main and cool down. You could combine some of the warming-up, locomotor and non-locomotor activities of creative games and skills with PE. • Allow learners to use their own apparatus or alternatively use the apparatus in groups on different days to allow for sanitizing. • All equipment to be washed down after every use (1 litre of water and 5 tablespoons of Jik) PLEASE NOTE, EVEN THOUGH ACTIVITIES HAVE BEEN PLOTTED PER WEEK, YOU MAY CHANGE THE ACTIVITIES TO SUIT YOUR NEED OR/AND CONTEXT	
	LOCOMOTOR Use own space at their chair or a demarcated area outside with clear markings (lanes can be drawn on tarmac- learners take turns 7 or 8 at a time dependent on the number of lanes- If no space, do not do the locomotor activities if learners are not self-regulating -spatial distancing)		
	Simulation (adapt) activities such as running like a horse, walk like a duck, jump like a frog, [waddle like a penguin], etc. on the spot		x
	PERCEPTUAL MOTOR		

Annual teaching plan extract: Grade 3, term 2, Life Skills			
CAPS Topic		Week 6	Week 7
		Healthy living	Insects
	Catch and throw a ball. Ball made from paper, easier to control	x	
	LATERALITY		
	Hand apparatus sequences such as short ribbons or scarf that requires left and right actions or similar kind.		x
	SPORTS AND GAMES		
	Indigenous games 5 stones played solo on their table	x	
	INFORMAL ASSESSMENT:	- The activities must be observed and assessed during daily lesson activities in Life Skills. Also note SKAVs that is developed and mastered for Home Language and Mathematics - Ensure that learners are afforded opportunities to demonstrate these skills practically. - This is informal and continuous.	
	SCHOOL BASED ASSESSMENT:	REFER TO DBE SBA Guidelines	

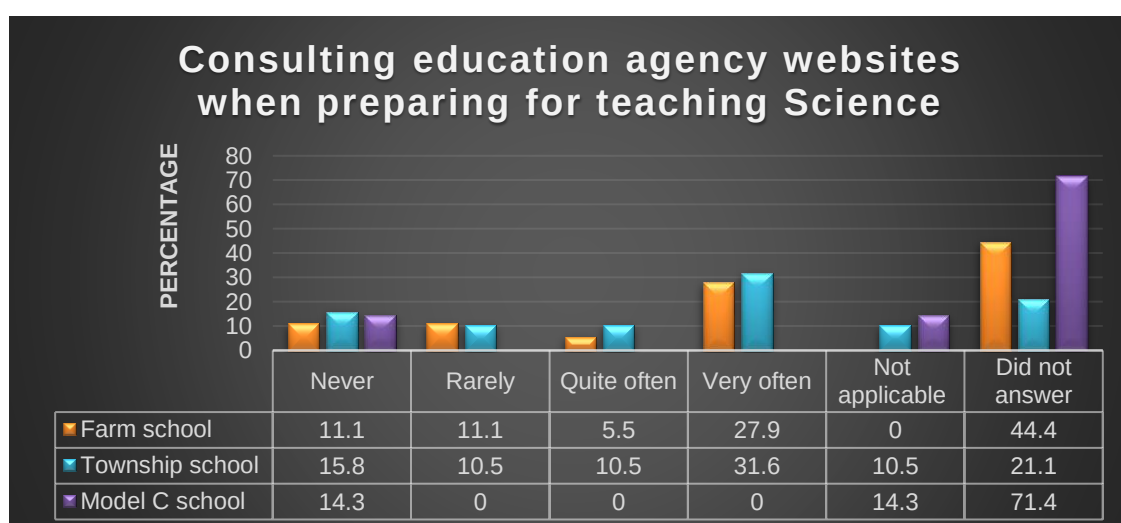


Figure 4-93: Consulting education agency websites in preparing for Science teaching

A total of 45.6% of the participating teachers opted not to answer this question. The majority of the remaining participants from Farm and Township schools indicated that they often made use of education agency websites when preparing to teach science. In contrast to this, the participants from the Model C school indicated that they never used education agency websites (see Figure 4-93).

In 2021, according to the NEIMS yearly report, there was a total of 23 276 public or government schools in South Africa (Department of Basic Education, 2021b). Of the 23 276 schools, only 6 938 had access to the internet for administrative purposes, and only 4 738 schools had access to the internet for teaching and learning (Department of Basic Education, 2021b). See Table 4-44 below for a breakdown of the availability of internet in South African schools.

Table 4-44: Schools in South Africa with internet access (Department of Basic Education, 2021b)

Availability of internet in South African schools					
Province	Number of schools in province	Internet connectivity for administrative purposes	% with internet connectivity for administrative purposes	Internet connectivity for teaching and learning	% with internet connectivity for teaching and learning
Western Cape	1 457	1 292	86.5	1 261	86.5
Eastern Cape	5 291	1 170	22.1	570	10.8
Northern Cape	544	408	75	215	39.5
Free State	1 084	391	36.1	303	28
KwaZulu-Natal	5 803	1 000	17.2	536	9.2
North West	1 471	650	44.2	276	18.8
Gauteng	2 074	1 441	69.5	1 327	64
Mpumalanga	1 718	241	14	99	5.8
Limpopo	3 834	345	8.9	151	3.9
Total	23 276	6 938	41.5	4 738	29.6

4.7.6 Question 35 of the adapted Creative Little Scientists questionnaire

Question 35 was “How often do you consult the following resources to inform your MATHEMATICS teaching preparation?”. See Table 4-45 below for a breakdown of the sub-questions and the Likert scale.

Take note that the first scale “never” – refers to the class or school having the resource but never using it. The scale indicating N/A – refers to not applicable because the participant does not have the resource in either their class or school.

Table 4-45: Resources used to inform Mathematic teaching preparation

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Textbooks					
b. Policy documents (school and national)					
c. Education agency website					

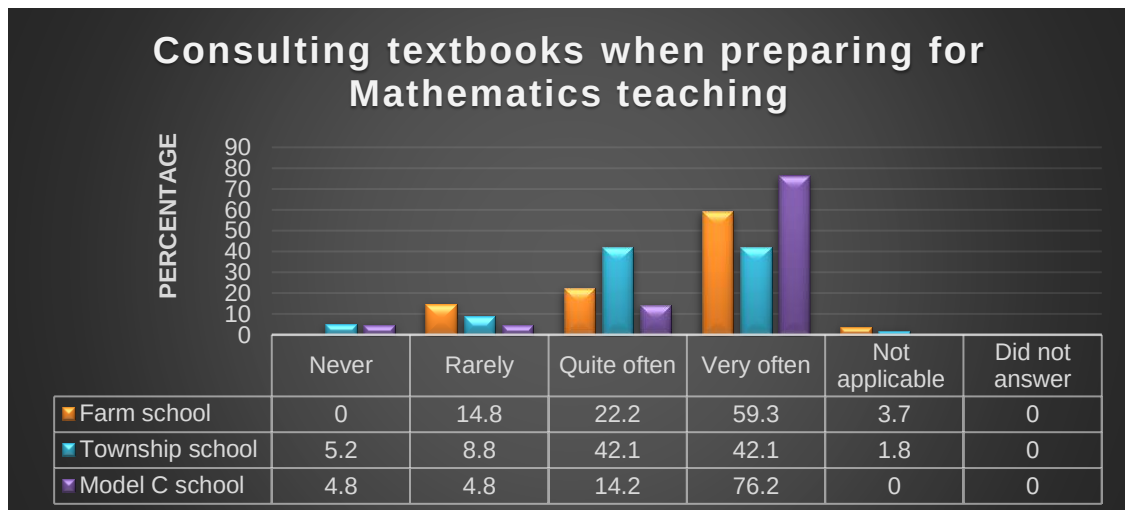


Figure 4-94: Consulting textbooks in preparing for Mathematics teaching

Most of the participants indicated that they often consulted textbooks when preparing for teaching activities in Mathematics. A higher number of the participants from Farm schools and the Model C school indicated that they very often made use of textbooks than the participants from Township schools (see Figure 4-94).

The ATP provides teachers with a list of resources to enhance learning, and teachers are prescribed to often make use of multiple resources to plan for weekly teaching and learning activities (Department of Basic Education, 2021a:3). From the above, it is clear that the majority of teachers make use of different textbooks to prepare for Mathematics teaching.

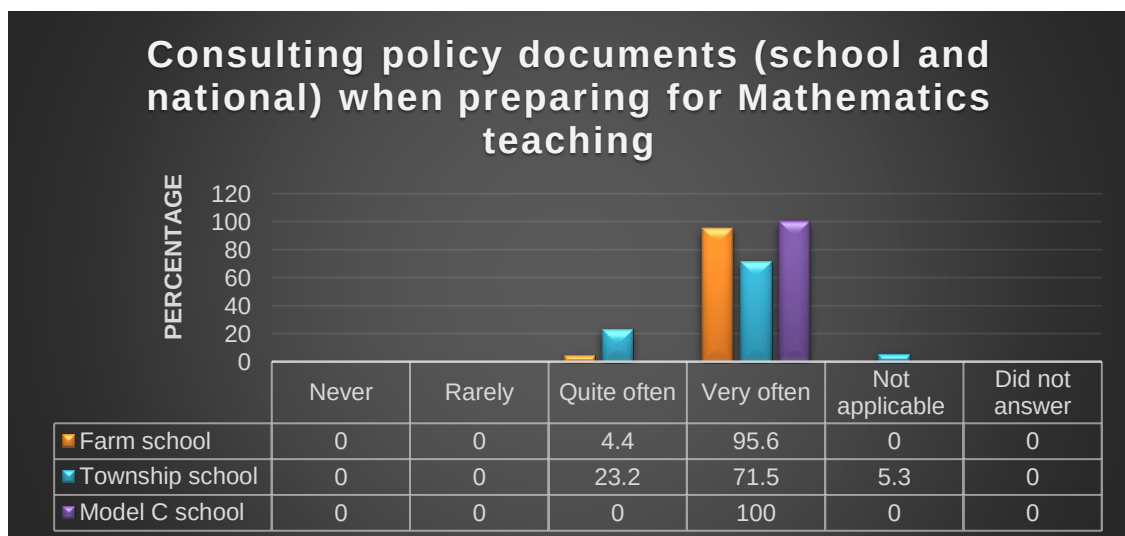


Figure 4-95: Consulting policy documents in preparing for Mathematics teaching

The majority of the participants indicated that they used policy documents very often when preparing for Mathematics teaching (see Figure 4-95).

As stated in the discussion of Question 34 (see Section 4.7.5), the ATP policy document provides teachers in each Grade with a detailed breakdown of the weeks of each term with the relevant CAPS topic, core concepts, skills and values, strategies of teaching, required pre-knowledge, a list of resources and the informal and formal assessment needed for the teaching and learning activities of that week (Department of Basic Education, 2021a:3-4). Table 4-46 below gives an example of the structure provided in the ATP for Mathematics.

The participants often make use of the above policy document, as it provides a clear structure for planning their weekly lessons, activities and assessment. The departmental workbook provided to each learner is designed with the policy documents as guiding structure.

Table 4-46: Extract from the Annual Teaching Plan for Mathematics (Department of Basic Education, 2021a:3-4)

Annual teaching plan extract: Grade 3, term 1, Mathematics			
	Week 1	Week 2-3	
CAPS Topic	<i>Baseline Assessment</i> NUMBER OPERATIONS & RELATIONSHIPS - Count objects - Count forwards and backwards - Number symbols and number - Place value	NUMBER OPERATIONS & RELATIONSHIPS - Count objects - Count forwards and backwards - Number symbols and number names - Describe, Order and Compare - Place value - Addition and Subtraction	
Core concepts, skills and values	Counting: - forwards and backwards in 2s, 5s and 10s up to 100 (from any multiples) MENTAL MATHS 1 more/1 less NUMBER OPERATIONS & RELATIONSHIPS - Counting concrete objects by grouping up to 100 (estimate and count reliably) - Complete number sequence up to 100 - Read and write number symbol up to 100 - Write number names 1 to 30 - Know what each digit represents - Decompose two digit numbers up to 99 into multiples of tens and ones/units - Identify and state the value of each digit. DBE Workbook:	Counting: (Number patterns integrated) - forwards and backwards in 1s, 2s, 5s up to 150 (from any multiples) MENTAL MATHS 1 more/1 less 2 more/2 less 5 more/ 5 less - Number bonds of 10	Counting: (Number patterns integrated) - forwards and backwards in 1s, 2s, 5s up to 150 (from any multiples) MENTAL MATHS - Order numbers - Smallest / biggest - Number bonds of 10 - Addition facts to 20
		NUMBER OPERATIONS & RELATIONSHIPS - Recognise, identify, read and write number symbols up to 200. - Write number names up to 100 - Order and compare (<, >, =) whole numbers up to 99 - Arrange from greatest to smallest, less than and is equal to up to 99 - Decompose two-digit numbers into multiples of tens and units/ones up to 99 - Identify and state the value of each digit - Solve addition and subtraction problems up to 20 in context - Use appropriate symbols (+, -, =, □)	

Annual teaching plan extract: Grade 3, term 1, Mathematics			
	Week 1	Week 2-3	
	Activity 1, 2, 3	DBE Workbook: Activity 4, 17, 18, 19	
Strategies	- Counting objects in more than 1 way - Clever counting (grouping) - Counting in multiples - Number line	- Expanded Notation, - Breaking down and building up - Number line	
Requisite pre-knowledge	In Grade 2, the learners should have learnt how to: - Count forwards and backwards from 0 to 200. - Recognise, read and write number symbols to 200. - Write number names to 100.	In Grade 2, the learners should have learnt how to: - Copy, extend and describe simple number sequences to at least 200, which should include counting forwards and backwards in ones. - Counting forwards in 10s, 5s, 4s, 3s and 2s up to 200. - Use apparatus, pictures, number lines, breaking down and building up of numbers when solving and explaining problems and performing calculations. - Solve word problems in context and explain own solution to problems involving addition and subtraction with answers to 99. - Number bonds to 10 as well as using the appropriate symbols: +, −, =, □	
Resources (other than textbook) to enhance learning	- Worksheets /classwork book - Concrete apparatus 100 board per learner - Activity cards - DBE Workbook	100 board - Worksheets / classwork book - Counters, abacus, - DBE Workbook	
Informal assessment	Assess as core concepts, skills and values above		
Formal assessment			Number operations & relations Oral

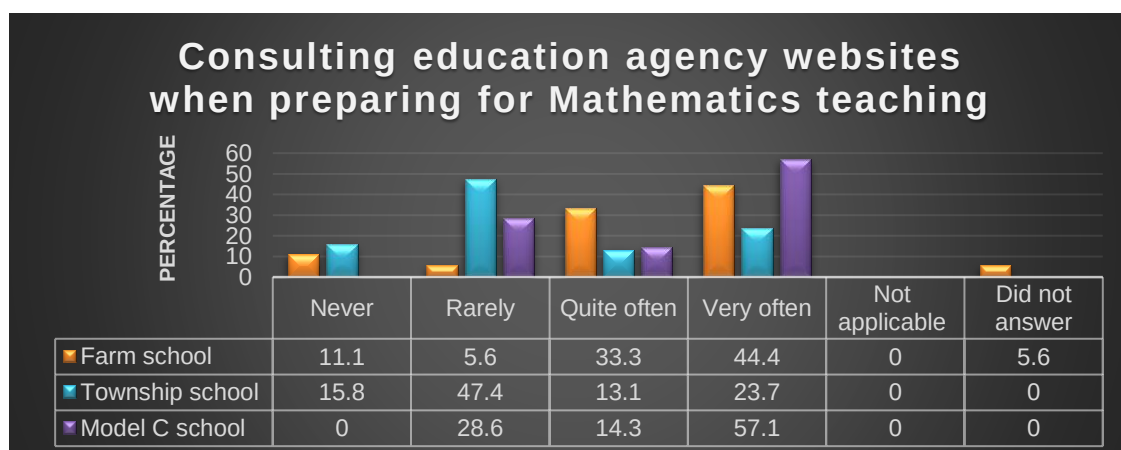


Figure 4-96: Consulting education agency websites in preparing for Mathematics teaching

Of the participating teachers, 1.9% opted not to answer the question on consulting education agency websites when preparing to teach Mathematics. The participants from Farm schools and the Model C school indicated that they used agency websites very often to prepare for

Mathematics lessons, whilst the majority of Township school participants indicated that they rarely made use of these websites.

The participants are from different types of schools in the North West province. As stated in the discussion of Question 34 (see Section 4.7.5), out of a total of 1 471 schools in North West Province, only 650 schools have access to internet connectivity for administration purposes, while only 276 of those schools have access to internet connectivity for teaching and learning purposes (Department of Basic Education, 2021b). Although there are multiple education websites available with content specific to South Africa (e.g. <https://wcedportal.co.za/lessons/foundation-phase>), the lack of access to internet connectivity at schools can explain why Township schools rarely make use of this resource.

4.7.7 Summary of the pedagogical phenomenon of resources

A summary of the results that emanated from Questions 30, 31, 32, 33, 34 and 35 includes i) the availability of resources for the teaching and learning activities in both Science and Mathematics in South Africa and ii) how often these teachers use available resources for the teaching and learning activities in both Science and Mathematics.

- i. The overall results from all three types of schools indicate that the participating schools are well equipped with library materials (storybooks and textbooks) and stationery for teaching Science and Mathematics. The participating schools, furthermore, indicated that they had basic equipment for teaching Science and were well equipped for teaching Mathematics. A lack of audio-visual resources and classroom support personnel for teaching Science and Mathematics was indicated at all three types of schools. There is a slight difference in the availability of resources of the Model C school in comparison to the Farm and Township schools. Overall, at all three types of schools, the Grade R classrooms are better equipped for teaching and learning activities than the classrooms of Grades 1 to 3.

The CAPS policy documents for both Life Skills and Mathematics provide teachers with a list of basic resources needed for teaching and learning activities (Department of Basic Education, 2011a:12-13; 2011b:16). The integrated nature of Life Skills, with a component of Creative Arts and Physical Education, requires more equipment, materials and stationery than Mathematics. The ATP policy document for both Life Skills and Mathematics elaborates further on the resources needed by providing teachers with a list of resources under the CAPS topics (Department of Basic Education, 2021a:3; 2021c:14-22).

- ii. The participating teachers from Farm and Township schools indicated that they often made use of library materials (storybooks and textbooks), teaching materials and hands-on equipment when teaching Science and Mathematics. The teachers from the Model C school indicated that they used the above when teaching Mathematics but not Science. ICT and audio-visual resources are only used by the participants from the Model C school. When preparing to teach Science and Mathematics, the participants mostly rely on making use of prescribed policy documents and library materials.

The prescribed policy documents for both Life Skills and Mathematics serve as the starting point for teachers when preparing for teaching, learning and assessment activities. The policy documents indicate to teachers when and what to teach, including the necessary resources, corresponding pages in the prescribed workbook and prescribed assessment (Department of Basic Education, 2021a:1-3; 2021c:14-22). The policy documents, however, do not prescribe how to the specific topics.

According to statistics on the availability of resources in South Africa, only 17.39% of public schools have access to a library stocked with books. Furthermore, 41.8% of public schools have access to a computer centre, but only 29.6% of schools have access to the internet for teaching and learning purposes (Department of Basic Education, 2021b). Delivery of books and stationery to schools (as seen in the example of the Eastern Cape in 2022) is a frequent occurrence (Van Schalkwyk *et al.*, 2022).

From the above, the policy documents for both Life Skills and Mathematics provide teachers with the necessary information on what learners need to attain during the course of a year. These documents are used by the teachers from all three types of schools as the starting point in preparing for teaching and learning activities in both these subjects.

4.8 Summary

This chapter dealt with the findings of this research, where three different types of South African schools (Farm schools, Township schools and a Model C school) were compared with regard to the teaching and learning of Science (described as Beginning Knowledge, which is a sub-component of Life Skills for Grades R to 3, in the South African curriculum documents) and Mathematics. This comparative inquiry of the teaching and learning of Science and Mathematics was conducted utilising four pedagogical phenomena, namely i) content and curriculum, ii) assessment, iii) instructional method and iv) resources.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Motivation for the inquiry

Currently, there is an international call for the development of STEM-related research looking at young children (Campbell & Speldewinde, 2022:2). This call resonates with the situation in South Africa regarding STEM education. Preliminary research done by Du Preez (2016:243) sets the stage by outlining the historic development of Beginning Knowledge as a subset of the Life Skills curriculum in Grades R to 3 in South Africa. Furthermore, Du Preez (2016:243) compares the development of the Beginning Knowledge curriculum in South Africa with the international body of scholarship. Du Preez (2016:245) states that the subject matter knowledge and pedagogical content knowledge of the Beginning Knowledge curriculum of South Africa are not yet on par with the guidelines for teaching Beginning Knowledge to learners in Grades R to 3 as described by international scholars.

A consecutive study by Van der Walt's (2020:16, 94, 149) study makes the recommendation that in order to teach STEM effectively to learners in Grades R to 3 in South Africa, the following issues should be considered:

- The nature (cognitive, social and emotional) of the young learner should be considered when teaching STEM. In other words, any teaching or learning should be developmentally appropriate.
- Based on the developmental appropriateness of the young learner, one of three teaching methodologies (play, play-world and IBSE) should be utilised.
- Taking into consideration both the developmental nature of the learner, coupled with a suitable teaching methodology, specific appropriate content domains should be selected for teaching STEM to learners in Grades R to 3.

It is imperative to remember that when talking about STEM in the context of Grades R to 3 in South Africa, it implies Mathematics and Science (described as Beginning Knowledge, which is a sub-component of Life Skills for Grades R to 3 in the South African curriculum documents).

In light of the above-mentioned, the researcher was prompted to build on the two studies investigating the phenomena of teaching STEM in the current South African context for Grades R to 3. This inquiry utilised the historical and theoretical assumptions and proceeded towards investigating actual real-time situations at grassroots level in South Africa. Therefore, the researcher aimed to compare the perceptions (practices and beliefs) of teachers with regard to

STEM guidance for teaching and learning in Grades R to 3 in three different types of schools (Farm schools, Township schools and Model C schools) in South Africa.

The researcher was fortunate to have an international study in the guise of the Creative Little Scientists consortium (Creative Little Scientists, 2012a). The Creative Little Scientists consortium designed a questionnaire that was standardised and utilised in nine countries and 13 education systems situated in the European region (Creative Little Scientists, 2012a:5). This researcher aimed to partially recreate the study of the Creative Little Scientists to make it the first African equivalent of this nature outside of the European context.

5.2 Results and answering the research questions

The overarching research question dealt with showcasing existing practices dealing with STEM as a transdisciplinary field of research for learners from Grades R, 1, 2 and 3 in South Africa. The research question was subsequently divided into four sub-questions, namely:

Research question 1: How are the content and curriculum of Mathematics and Science Grades R to 3 conceptualised by teachers from different types of schools (and in policy) in South Africa?

The findings with regard to the pedagogical phenomenon of content and curriculum were as follows:

- The participating teachers spend more time during a week teaching Mathematics compared to teaching Science.
- Mathematics content is described in the official policy documents with a clear developmental structure as reference for teachers to follow, while the Science content does not have the same clear developmental structure. The Science content falls within the learning area of Beginning Knowledge of the Life Skills subject. The content from this learning area (Beginning Knowledge) is used as context in the other learning areas, namely Personal and Social Well-being, Creative Arts and Physical Education, in Life Skills.
- Mathematics teachers only have policy guidelines with regard to content knowledge per se, but no guidelines with regard to fostering an understanding of, communication in or a positive attitude towards Mathematics in young learners. This is in contrast with the policy guidelines for Science (Life Skills), which are focused on fostering all four aspects, namely content knowledge, understanding, communication and a positive attitude towards Science in young learners.
- The findings reflected that there was no difference relating to content and curriculum between the three different types of schools.

Research question 2: How does the assessment of Mathematics and Science affect teaching and learning activities in Grades R to 3 in different types of schools (and in policy) in South Africa?

The findings with regard to the pedagogical phenomenon of assessment were as follows:

- In both Mathematics and Science, Grade R learners are only evaluated by teachers observing what they do, and these evaluations are scored by utilising checklists and rubrics. In other words, no formal assessment takes place in Grade R.
- Assessment for Grade 1 to 2 learners for Mathematics consists of oral, practical and written with an emphasis on more assessment of written work. Grade 3 learners are mostly assessed on written work.
- In contrast to the assessment situation of Mathematics in Grade 1 to 3, in Science, assessment takes place by evaluating learners' oral and practical work and less emphasis on written work.
- The findings reflected that there was no difference relating to assessment between the three different types of schools.

Research question 3: What methods (inquiry-based, creativity and play) are used in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?

The findings with regard to the pedagogical phenomenon of instructional method were as follows:

- For both Mathematics and Science, there was no clear indication in the policy documents as to the required instructional method that needs to be followed.
- For both Mathematics and Science teaching, it was indicated by the teachers that they preferred inquiry as a teaching methodology. However, they contradicted themselves in a follow-up question by indicating that they would do it through demonstrations.
- The findings reflected that there was no difference relating to the instructional method used by teachers between the three different types of schools.

Research question 4: What role does the availability of resources play in the teaching of Mathematics and Science in Grades R to 3 by teachers from different types of schools (and in policy) in South Africa?

The findings with regard to the pedagogical phenomenon of resources were as follows:

- The policy documents for Science (Life Skills) provide an expansive list of possible materials that can be used to teach and learn Science, in contrast to the limited list prescribed by the Mathematics policy documents. The teachers of Mathematics and Science indicated ample availability of resources for teaching both subjects.

- The teachers indicated that they frequently used library materials, teaching materials and hands-on equipment for Mathematics and Science teaching and learning activities.
- The data relating to the availability of resources showed that this was the only instance where there was a difference between the Model C school, the Farm schools and the Township schools. The Model C school had more stationery and ICT and audio-visual resources available than the other two types of schools.

5.3 Similarities and differences in findings between this research and the Creative Little Scientists study

The researcher is of the opinion that it should be of general pedagogical interest to show the similarities and differences between the European study and the South African study.

5.3.1 Similarities between this research and the Creative Little Scientists study

The literature and findings of the South African inquiry share similarities with those of the Creative Little Scientists study. These similarities include the following:

- i. The Creative Little Scientists consortium found that the rationale of the curriculum of nearly all the investigated countries indicated that the aim of the curriculum was to develop learners holistically and empower these learners as citizens (Creative Little Scientists, 2014b:14). The literature on the South African curriculum for both Mathematics and Science (Life Skills) also indicated that the aim of the curriculum was to prepare learners holistically and to live meaningful and successful lives in a rapidly changing society (Department of Basic Education, 2011a:8; 2011b:8).
- ii. The Creative Little Scientists study indicated that policy documents in the participating countries placed an emphasis on the development of learners' knowledge and understanding, while placing little to no focus on communication or fostering a positive attitude towards learning Mathematics and Science (Creative Little Scientists, 2014b:15). The findings from the South African context indicated that the policy documents on Mathematics put the same emphasis on learners' knowledge and understanding. The policy documents for Science differ by focusing on the development of learners' knowledge and understanding of, communication in and a positive attitude towards Science.
- iii. The Creative Little Scientists study found that there was a dissonance between the time required to complete the prescribed curriculum for Mathematics and Science versus the time available in school timetable settings (Creative Little Scientists, 2014b:19). Similarly, the literature on the policy documents of South Africa indicated that less time was

allocated to teaching Science compared to Mathematics (Department of Basic Education, 2011a:6). Furthermore, the actual research findings from this inquiry indicated that the teachers spent far less time teaching Science than Mathematics.

- iv. The Creative Little Scientists study highlighted formal assessment as important for learner development, as indicated by both teachers and policy documents (Creative Little Scientists, 2014b:16). Both the literature and the findings from the South African context indicated assessment as a key part of the teaching and learning activities (Department of Basic Education, 2011a:66).
- v. Furthermore, a common trend was seen in the participating countries of the Creative Little Scientists study where the focus of assessment was on the products produced by learners rather than the processes in Science and Mathematics (Creative Little Scientists, 2014b:17). The literature and findings with regard to the assessment of South African learners in Grades R to 3 indicated that only Grade R learners are assessed holistically when engaging in play-based activities (Department of Basic Education, 2018c:2). The assessment of learners in Grades 1 to 3 mimics the findings from the Creative Little Scientists consortium, where learners are assessed based on their products only and not the process (Department of Basic Education, 2011a:66; 2011b:8-9).

5.3.2 Differences between this research and the Creative Little Scientists study

There were also some differences in the literature and findings of the South African inquiry and those of the Creative Little Scientists study. These differences include the following:

- i. The Creative Little Scientists study found that the instructional method of inquiry formed a key part of the teaching and learning activities for Mathematics and Science (Creative Little Scientists, 2014b:14). Neither the literature nor the findings from research done by the researcher from South Africa indicated that inquiry as an instructional method formed a key part of teaching Mathematics or Science (Life Skills).
- ii. Furthermore, the Creative Little Scientists study observed teachers making use of different instructional methods that foster learners' inquiry in both Mathematics and Science (Creative Little Scientists, 2014b:17-18). From the literature and research findings of the South African study, it is seen that while in the Science curriculum some mention is made of fostering self-regulation in learners (Department of Basic Education, 2021c:11-22), the Mathematics curriculum does not reflect any instructional methods (Department of Basic Education, 2021a:1). Furthermore, the participating teachers indicated a preference for guiding learners instead of allowing learners to self-regulate their activities.
- iii. A major difference between the South African inquiry and the Creative Little Scientists study was that the Creative Little Scientists study did not report on the issue of the

availability and use of resources, while it formed a major component of the South African findings.

In summary, South Africa is on par with the countries reported on in the Creative Little Scientists project when dealing with the content, curriculum and assessment of Mathematics. South Africa is also on par with the countries of the Creative Little Scientists project in terms of the content, curriculum and assessment per se of Science, although in the case of South Africa, it is camouflaged in a complexly structured policy document. However, South Africa is not on par with the countries of the Creative Little Scientists project when it comes to instructional methods for Science and Mathematics. Lastly, no comparison can be made regarding the availability of resources in the country, seeing that the Creative Little Scientists study did not report on this matter.

5.4 Recommendations

The following recommendations with regard to the four pedagogical phenomena are made based on the research findings:

Content and curriculum

- More time needs to be allocated for teaching Science as part of Life Skills in order to better prepare learners for the requirements of the Natural Science and Technology subjects in Grade 4.
- The clear developmental structure followed in the Mathematics curriculum for Grades R to 3 can serve as a framework for designing a more functional Science curriculum in policy documents.
- The Mathematics curriculum mainly emphasises content, while the Science curriculum emphasises both content and the development of skills and values. Therefore, it would be beneficial if Mathematics followed suit.

Assessment

- There is a need in both Science and Mathematics assessment to focus on the processes and not just the product. Teachers need to be aware of and trained in the purpose of each assessment tool in order to utilise the correct form of assessment for the related content in both Science and Mathematics. Mathematics policy documents need to re-evaluate the use of written assessment as the main focus in Grades 1 to 3.

Instructional methods

- Policy documents for both Science and Mathematics need to include guidelines on selecting and implementing pedagogically appropriate instructional methods (play, play-world and IBSE) for teaching and learning activities.
- Teachers may benefit from being exposed to continuous professional development interaction, which deals with a range of pedagogically appropriate instructional methods specific to Science and Mathematics.

Resources

- Policy documents for both Mathematics and Science need to elaborate and provide guidelines for teachers on how to use prescribed resources.
- The provision of resources that are age- and subject-specific in both the domains of Science and Mathematics needs to be addressed by the National Department of Education to ensure that effective teaching and learning take place, while also ensuring equal access to resources for all learners in all types of schools.

5.5 Extrapolations from the research findings

The recommendations provided above were made based on the evidence that emerged from the data that had been gathered utilising the adapted Creative Little Scientists questionnaire, policy documents, maps of the spaces, individual follow-up interviews and artefacts. These recommendations can be extrapolated to address issues that were not directly measured in this research, namely:

With regard to the content and curriculum of Science, the participating teachers' subject-specific knowledge did not seem to be adequate, either because of the way the curriculum is structured or because of insufficient continuous professional development. The mere fact that it seemed that some teachers were not aware of the fact that they were actually teaching Science was indicative of this problem (see Beni *et al.*, 2017:6). This implies that either the content-specific knowledge of teachers needs to be addressed with professional development courses or the policy documents for Science need to be simplified (Dixon, 2018:20).

Concerning instructional methods, the seemingly contradictory interpretation of Question 21 (see Figures 4-61 and 4-62) by the teachers points to the possibility that the teachers were not knowledgeable about the types of teaching methodologies and their implications for teaching specific content at a specific age in STEM. This issue has implications for policy document clarification, which falls in the realm of the National Education Department.

With regard to resources, although the teachers indicated that there was adequate availability of resources, the actual situation that was observed did not correlate with policy document prescriptions. In other words, while the policy documents mention extensive lists of resources that teachers should have access to, in reality, very few of these resources were observed when the researcher analysed the maps of the spaces. This implies that either the teachers do not have access to these resources or they do not deem it necessary to use them.

In general, during teacher training, Mathematics as a subject domain is dealt with extensively over the entirety of a four-year diploma or degree period. Contrary to that, the subject Life Skills, with Science education as a subset, is dealt with far less. This has a knock-on effect that has an impact on postgraduate teacher training in the STEM domains of the Grades R to 3 phase. This situation, which has a historical connotation, has led to offering no or little specialisation in STEM at the level of Grades R to 3 in undergraduate teacher training. This means that currently, there is a shortage of individuals, both at lecturer level and official governmental management level, with specialist knowledge in STEM education for Grades R to 3.

5.6 Future areas for research

More research is needed to shed more light on the following:

Firstly, research is needed to validate the appropriateness of the current Science (Life Skills) curriculum, especially in light of the new Coding and Robotics curriculum that has been prescribed for South Africa from 2022.

Secondly, research is needed to understand the interplay among the different teaching pedagogies for the different developmental stages of learners in Grades R to 3.

Lastly, more research is needed to understand the contribution of not only non-digital but also digital resources in teaching and learning in the STEM fields.

5.7 Coda

Currently, South Africa is joining the rest of the world in prescribing curricula dealing with Coding and Robotics for Grades R to 3 (Department of Basic Education, 2021f:2). This content domain forms an important part of the STEM field of education. In light of the above-mentioned extrapolated recommendations, the following issues will have to be addressed upfront in order for the Coding and Robotics curricula to not repeat the mistakes evident from the Science domain in

Grades R to 3 in South Africa. In other words, attention will have to be paid to the following aspects:

- Sufficient time needs to be allocated for teaching Coding and Robotics.
- Relevant teacher training for both preservice and in-service teachers addressing Coding and Robotics will be needed.
- Adequate unplugged and plugged-in (e.g. tablets and computers) resources need to be made available to all learners in all different types of schools in South Africa.

In conclusion MacDonald *et al.* (2022:352) state that:

... the development of Science, Technology, Engineering, and Mathematics (STEM) curricula varies in quality in the early childhood years, making STEM instructions inconsistent between and within different preschool and early elementary grade levels. Given that fundamental STEM reasoning and thinking are established in early education, this lack of curricula development and the uneven manner in which it is deployed is problematic.

The author of this inquiry supports the above-mentioned view of MacDonald *et al.* (2022:352) and calls for a concerted effort to be taken by all role players involved in all aspects of the teaching and learning of STEM in South Africa to work together to develop a better-prepared 21st-century citizenry starting as early as Grades R to 3.

BIBLIOGRAPHY

Anderson, R.B. 2020. "To save a soul": Catholic mission schools, Apartheid, and the 1953 Bantu Education Act. *Journal of Religious History*, 44(2):149-167.

Anon. 2018a. Miles Kimball. <https://www.mileskimball.com/buy-traditional-russian-nesting-dolls-set-of-5-313226> Date of access: 23 Apr. 2022.

Anon. 2018b. *Russian Legacy*. Matryoshka: Russian wooden nesting dolls. <https://russianlegacy.com/matryoshka-nesting-dolls.htm> Date of access: 23 Apr. 2022.

Ary, D., Jacobs, L.C., Irvine, C.K.S. & Walker, D. 2018. *Introduction to research in education*. Boston, MA: Cengage Learning.

Bahari, S.F. 2010. Qualitative versus quantitative research strategies: contrasting epistemological and ontological assumptions. *Sains Humanika*, 52(1):17-28.

Ball, D.L., Thames, M.H. & Phelps, G. 2008. Content knowledge for teaching: what makes it special? *Journal of Teacher Education*, 59:389-407.

Bayaga, A. & Nzuza, P. 2022. Examining challenges associated with numerical cognition in early years challenges associated with numerical cognition in early years. *International Journal on Research in STEM Education*, 4(1):1-14.

Beni, S., Stears, M. & James, A. 2017. Foundation Phase teachers' interpretation of the Life Skills programme with regard to the teaching of Natural Science. *South African Journal of Childhood Education*, 7(1):1-14.

Booth, J.L., McGinn, K.M., Barbieri, C., Begolli, K.N., Chang, B., Miller-Cotto, D., Young, L.K. & Davenport, J.L. 2017. Evidence for cognitive science principles that impact learning in mathematics. In: Geary, D.C., Berch, D.B., Ochsendorf, R.J. & Koepke, K.M., eds. *Acquisition of complex arithmetic skills and higher-order mathematics concepts*. 3rd ed. London: Academic Press. pp. 297-317.

Bredo, E. 2006. Philosophies of educational research. In: Green, J.L., Camilli, G. & Elmore, P.B., eds. *Handbook of complementary methods in education research*. Washington, DC: American Educational Research Association. pp. 3-32.

- Breiner, J.M., Harkness, S.S., Johnson, C.C. & Koehler, C.M. 2012. What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics*, 112(1):3-11.
- Bryan, L.A., Moore, T.J., Johnson, C.C. & Roehrig G.H. 2016. Integrated STEM education. Chapter 3. In: Johnson, C.C., Peters-Burton, E.E & Moore, T.J., eds. *STEM road map: a framework for integrated STEM education*. New York NY: Routledge. pp. 23-38.
- Bybee, R., McCrae, B. & Laurie, R. 2009. PISA 2006: an assessment of scientific literacy. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching*, 46(8):865-883.
- Bybee, R.W. 2010. Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, 70(1):30-35.
- Campbell, C. & Speldewinde, C. 2022. Early childhood STEM education for sustainable development. *Sustainability*, 14(6):1-11.
- Cekiso, M., Meyiwa, T. & Mashige, M. 2019. Foundation Phase teachers' experiences with instruction in the mother tongue in the Eastern Cape. *South African Journal of Childhood Education*, 9(1):1-14.
- Chappell, K., Craft, A., Burnard, P. & Cremin, T. 2008. Question-posing and question-responding: the heart of "possibility thinking" in the early years. *Early Years*, 28(3):267-286.
- Chukwuedo, S.O. & Uko-Aviomoh, E.E. 2015. Building theoretical and conceptual frameworks for quantitative research report in education. *African Journal of Studies in Education*, 10(2):83-101.
- Clements, D.H. 2000. "Concrete" manipulatives, concrete ideas. *Contemporary Issues in Early Childhood*, 1(1):45-60.
- Clough, P. & Nutbrown, C. 2010. *A student's guide to methodology*. 2nd ed. London: Sage.
- Connor, A.M., Karmokar, S. & Whittington, C. 2015. From STEM to STEAM: strategies for enhancing engineering & technology education. *International Journal of Engineering Pedagogy*, 5(2):37-47.
- Constantinou, C., Tsivitanidou, E. & Rybska, E. 2018. What is inquiry-based science teaching and learning? In: Tsivitanidou, O., Gray, P., Rybska, E., Louca, L. & Costantinou, C., eds.

Professional development for inquiry-based science teaching and learning. Cham: Springer. pp. 1-23.

Costantino, T. 2018. STEAM by another name: transdisciplinary practice in art and design education. *Arts Education Policy Review*, 119(2):100-106.

Creative Little Scientists. 2011. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D2.1 guidelines for the background literature reviews. http://www.creative-little-scientists.eu/sites/default/files/D2.1_Guidelines_for_Literature_Review.pdf Date of access: 25 May 2022.

Creative Little Scientists. 2012a. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D3.3 report on first survey of school practice. http://www.creative-little-scientists.eu/sites/default/files/D3.3_Report_on_First_Survey_of_School_Practice_FINAL.pdf Date of access: 20 May 2022.

Creative Little Scientists. 2012c. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D2.2 conceptual framework addendum 2 of 4: literature review of creativity in education. <http://www.creative-little-scientists.eu/sites/default/files/Addendum%20%20Creativity%20in%20Ed%20FINAL.pdf> Date of access: 21 May 2022.

Creative Little Scientists. 2012d. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D2.2 conceptual framework addendum 1 of 4: literature review of Science and Mathematics education. <http://www.creative-little-scientists.eu/sites/default/files/Addendum%201%20Science%20and%20Mathematics%20Ed%20FINAL.pdf> Date of access: 21 May 2022.

Creative Little Scientists. 2012e. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D2.2 conceptual framework addendum 4 of 4: literature review of comparative education. <http://www.creative-little-scientists.eu/sites/default/files/Addendum%201%20Science%20and%20Mathematics%20Ed%20FINAL.pdf> Date of access: 17 May. 2022.

Creative Little Scientists. 2012f. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education*. D4.1 methodology for in-

depth fieldwork. http://www.creative-little-scientists.eu/sites/default/files/D4_1_Methodology_of_in-depth_field_work_FINAL.pdf Date of access: 23 Apr. 2022.

Creative Little Scientists. 2014a. *Creative Little Scientists: enabling creativity through Science and Mathematics in preschool and first years of primary education. D6.6 set of recommendations to policy makers and stakeholders.* http://www.creative-little-scientists.eu/sites/default/files/D6_6_Recommandations_to_Policy_Makers_and_Stakeholders_FINAL.pdf Date of access: 23 Apr. 2022.

Creative Little Scientists. 2014b. *Creativity in Science and Mathematics education for young children: executive summary.* http://www.creative-little-scientists.eu/sites/default/files/Creativity_in_Science_and_Mathematics_Education.pdf Date of access: 7 Jun. 2022.

Cremin, T., Glauert, E., Craft, A., Compton, A. & Stylianidou, F. 2015. Creative Little Scientists: exploring pedagogical synergies between inquiry-based and creative approaches in Early Years Science. *Education 3-13*, 43(4):404-419.

Creswell, J.W. 2008. *Educational research: planning, conducting, and evaluation quantitative and qualitative research*. 3rd ed. New Jersey, NJ: Pearson Education.

Creswell, J.W. 2014. *Research design: qualitative, quantitative and mixed methods approaches*. 4th ed. Thousand Oaks, CA: Sage.

De Beer, Z.L. & Vos, D. 2021. BRICS as a supranational taxon for comparative education. In: Wolhuter, C.C. & Steyn, H.J., eds. *Critical issues in education systems: comparative-international perspective*. Noordbrug: Keurkopie. pp. 87-114.

Deng, Z. & Luke, A. 2008. Subject matter: defining and theorizing school subjects. In: Connelly, F.M., He, M.F. & Phillion, J., eds. *Sage handbook of curriculum and instruction*. Thousand Oaks, CA: Sage. pp. 1-31.

Department of Basic Education (South Africa). 2010. *Education information standards: dictionary of education concepts and terms 2010.* <https://www.education.gov.za/Portals/0/Documents/Publications/Dictionary%20of%20Education%20final.pdf?ver=2015-01-29-112633-100> Date of access: 16 Apr. 2022.

Department of Basic Education (South Africa). 2011a. *Curriculum and assessment policy statement Grades R-3 (CAPS): Life Skills*.

<https://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20Life%20Skills%20%20English%20%20Gr%20R-3%20FS.pdf?ver=2015-01-27-162204-953> Date of access: 9 Apr. 2022.

Department of Basic Education (South Africa). 2011b. *Curriculum and assessment policy statement Grades R-3 (CAPS): Mathematics*.

<https://www.education.gov.za/Portals/0/CD/National%20Curriculum%20Statements%20and%20Vocational/CAPS%20MATHS%20%20ENGLISH%20GR%201-3%20FS.pdf?ver=2015-01-27-160947-800> Date of access: 9 Apr. 2022.

Department of Basic Education (South Africa). 2015. *The South African National Curriculum Framework for children from birth to four. Comprehensive version*. Pretoria: Department of Basic Education. <https://www.unicef.org/southafrica/media/911/file/SAF-national-curriculum-framework-0-4-En.pdf> Date of access: 25 May. 2022.

Department of Basic Education (South Africa). 2017. *Mathematics in English: Grade 3 – Book 2, term 3 & 4*. 7th ed. Pretoria: Department of Basic Education.

Department of Basic Education (South Africa). 2018a. *Foundation Phase, Mathematics, SBA exemplar booklet: Grade 1-3*.

<https://www.education.gov.za/Portals/0/CD/SBA%20BOOKLETS%202018/Foundation%20Mathematics%20%20Grades%201%20-%203.pdf?ver=2018-03-08-161742-000> Date of access: 30 Apr. 2022.

Department of Basic Education (South Africa). 2018b. *Foundation Phase, Life Skills, SBA exemplar booklet: Grade 1-3*.

<https://www.education.gov.za/Portals/0/CD/SBA%20BOOKLETS%202018/Foundation%20Life%20Skills%20Grades%201%20-%203.pdf?ver=2018-03-08-161732-000> Date of access: 30 Apr. 2022.

Department of Basic Education (South Africa). 2018c. *Foundation Phase, Grade R, SBA exemplar booklet*. <https://wcedportal.co.za/eresource/69301> Date of access: 30 Apr. 2022.

Department of Basic Education (South Africa). 2019. *Life Skills in English: Grade 2 – Book 1, term 1 & 2*. 9th edition. Pretoria: Department of Basic Education.

Department of Basic Education (South Africa). 2021a. *2021 Annual teaching plan – Term 1: Mathematics Grade 3*.

<https://www.education.gov.za/Portals/0/Documents/Recovery%20plan%20page/2021%20ATPs/>

[Foundation%20Phase/Mathematics%20FP/English/2021%20Mathematics%20ATP%20Grade%203%20Term%201.pdf?ver=2021-02-04-160842-000](https://www.education.gov.za/Portals/0/Documents/Reports/NEIMS%20STANDARD%20REPORT%202021.pdf?ver=2021-02-04-160842-000) Date of access: 18 Apr. 2022.

Department of Basic Education (South Africa). 2021b. *National Education Infrastructure Management System Report as at 12 April 2021*.

<https://www.education.gov.za/Portals/0/Documents/Reports/NEIMS%20STANDARD%20REPORT%202021.pdf?ver=2021-05-20-094532-570> Date of access: 18 Apr. 2022.

Department of Basic Education (South Africa). 2021c. *2021 Annual teaching plan – Grade 3: Life Skills*.

<https://www.education.gov.za/Portals/0/Documents/Recovery%20plan%20page/2021%20ATPs/Foundation%20Phase/Life%20Skills%20FP/English/2021%20LIFE%20SKILLS%20ATP%20GRADE%203.pdf?ver=2021-01-27-202201-183> Date of access: 20 Apr. 2022.

Department of Basic Education (South Africa). 2021d. *Workbooks*.

[https://www.education.gov.za/Curriculum/LearningandTeachingSupportMaterials\(LTSM\)/Workbooks.aspx](https://www.education.gov.za/Curriculum/LearningandTeachingSupportMaterials(LTSM)/Workbooks.aspx) Date of access: 30 Apr. 2022.

Department of Basic Education (South Africa). 2021e. *2021 Recovery Annual teaching plan – Term 2: Mathematics Grade R*.

https://www.education.gov.za/Portals/0/Documents/Recovery%20plan%20page/2021%20ATPs/Foundation%20Phase/Grade%20R/2021%20ATP%20Mathematics%20Grade%20R%20Term%202_FINAL.pdf?ver=2021-04-26-092822-000 Date of access: 23 Apr. 2022.

South Africa. Department of Basic Education. 2021f. *Draft Curriculum and Assessment Policy Statement Grades R-3: CODING AND ROBOTICS*.

<https://www.education.gov.za/Portals/0/Documents/Legislation/Call%20for%20Comments/draftcodingandroboticscurriculum/Grade%20R-3%20Coding%20and%20Robotics%20Draft%20CAPS%20Final%2019Mar2021.pdf?ver=2021-03-24-164612-000> Date of access 29 Jun. 2022.

Department of Basic Education (South Africa). 2022a. *2021 Systemic test results confirm devastating impact of Covid-19 on education*. <https://www.gov.za/speeches/justice-crime-prevention-and-security-jcps-cluster-briefing-statement-state-nation-1> Date of access: 14 Jun. 2022.

Department of Basic Education (South Africa). 2022b. *School realities 2021*.

<https://www.education.gov.za/Portals/0/Documents/Reports/School%20Realities%202021.pdf?ver=2022-02-07-094832-243> Date of access: 27 May. 2022.

Dixon, K., Janks, H., Botha, D., Earle, K., Poo, M., Oldacre, F., Pather, K. & Schneider, K. 2018. A critical analysis of CAPS for Life Skills in the Foundation Phase (Grades R-3). *Journal of Education*, 71:6-23.

Du Preez, H. 2016. *A historical subject-didactical genetic analysis of Life Skills education in early childhood*. Potchefstroom: North-West University. (Thesis – PhD).

Durmus, S. & Karakirik, E. 2006. Virtual manipulatives in mathematics education: a theoretical framework. *Turkish Online Journal of Educational Technology*, 5(1):117-123.

Ellis, C., Bochner, A., Denzin, N., Lincoln, Y., Morse, J., Pelias, R. & Richardson, L. 2008. Talking and thinking about qualitative research. *Qualitative Inquiry*, 14(2):254-284.

English, L.D. 2015. STEM: challenges and opportunities for mathematics education. In: Muir, T., Wells, J. & Beswick, K., eds. *Proceedings of the 39th Meeting of the International Group for the Psychology of Mathematics Education*, 39(1):4-18.

Ergazaki, M. & Zogza, V. 2013. How does the model of inquiry-based science education work in the kindergarten: the case of Biology. *Review of Science, Mathematics and ICT Education*, 7(2):73-97.

European Schoolnet. 2012. *Science, technology, engineering and mathematics education: overcoming challenges in Europe*. http://www.ingenious-science.eu/c/document_library/get_file?uuid=3252e85a-125c-49c2-a090-eaeb3130737a&groupId=10136 Date of access: 6 Jun. 2022.

Fensham, P.J. & Harlen, W. 1999. School science and public understanding of science. *International Journal of Science Education*, 21(7):755-763.

Fleer, M. 2019. Scientific playworlds: a model of teaching science in play-based settings. *Research in Science Education*, 49(5):1257-1278.

Foot, K.A. 2014. Cultural-historical activity theory: exploring a theory to inform practice and research. *Journal of Human Behavior in the Social Environment*, 24(3):329-347.

Fragkiadaki, G., Fleer, M. & Ravanis, K. 2021. Understanding the complexity of young children's learning and development in science: a twofold methodological model building on constructivist and cultural-historical strengths. *Learning, Culture and Social Interaction*, 28:100461.

French, L. 2004. Science as the center of a coherent, integrated early childhood curriculum. *Early Childhood Research Quarterly*, 19(1):138-149.

Giese, S., Dawes, A., Tredoux, C., Mattes, F., Bridgman, G., Van der Berg, S., Schenk, J. & Kotzé, J. 2022. *Thrive by Five Index Report*. Cape Town: Innovation Edge.

www.thrivebyfive.co.za Date of access: 1 Jun. 2022.

Giliomee, H. 2009. A note on Bantu education, 1953 to 1970. *South African Journal of Economics*, 77(1):190-198.

Gire, E., Carmichael, A., Chini, J.J., Rouinfar, A., Rebello, S., Smith, G. & Puntambekar, S. 2010. The effects of physical and virtual manipulatives on students' conceptual learning about pulleys. *Proceedings of the 9th International Conference of the Learning Sciences*, 1:937-943.

Global Media. 2017. *ExpatArrivals: local info for global expats*.

<http://www.expattarrivals.com/south-africa/education-and-schools-in-south-africa> Date of access: 21 Apr. 2022.

Goswami, U. 2015. Children's cognitive development and learning. *Cambridge Primary Review Trust*:1-42.

Hakkarainen, P., Brédikyté, M., Jakkula, K. & Munter, H. 2013. Adult play guidance and children's play development in a narrative playworld. *European Early Childhood Education Research Journal*, 21(2):213-225.

Handal, B. & Herrington, A. 2003. Mathematics teachers' beliefs and curriculum reform. *Mathematics Education Research Journal*, 15(1):59-69.

Harlen, W. 2012. *Developing policy, principles and practice in primary school science. Report from a working group led by Professor Wynne Harlen July 2012 assessment*.

http://www.nuffieldfoundation.org/sites/default/files/files/Developing_policy_principles_and_practice_in_primary_school_science_assessment_Nuffield_Foundation_v_FINAL.pdf Date of access: 14 Apr. 2022.

Hens, L., Wiedemann, T., Raath, S., Stone, R., Renders, P. & Craenhals, E. 2010. Performance of newly implemented environmental management systems in primary schools in South Africa. *Journal of Environmental Management*, 91(4):906-917.

Johnson, B. & Christensen, L. 2008. *Educational research: quantitative, qualitative, and mixed approaches*. 3rd ed. London: Sage.

Johnson, C.C. 2013. Conceptualizing integrated STEM education. *School Science and Mathematics*, 113(8):367-368.

- Johnson, V.M. 1998. *An investigation of the effects of instructional strategies on conceptual understanding of young children in mathematics*. University of California: Riverside. (Thesis – PhD).
- Kansteiner, K. & König, S. 2020. The role(s) of qualitative content analysis in mixed methods research designs. *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research*, 21(1):1-22.
- Klahr, D., Triona, L.M. & Williams, C. 2007. Hands on what? The relative effectiveness of physical versus virtual materials in an engineering design project by middle school children. *Journal of Research in Science Teaching*, 44(1):183-203.
- Knight, S.A. & Cross, D. 2012. Using contextual constructs model to frame doctoral research methodology. *International Journal of Doctoral Studies*, 7:39-62.
- Knoblauch, H., Baer, A., Laurier, E., Petschke, S. & Schnettler, B., 2008, September. Visual analysis. New developments in the interpretative analysis of video and photography. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research* (Vol. 9, No. 3).
- Koumara, A. & Plakitsi, K. 2017. The nature of science in lower secondary school: the case of Greece. *Science Education: Research and Praxis*, 104-113.
- Krishna, A.R. 2013. *From OBE to CAPS: educators' experiences of the new Life Skills curriculum in the Foundation Phase*. Durban: University of KwaZulu-Natal. (Dissertation – MEd).
- Lamon, W.E. & Huber, L.E. 1971. The learning of the vector space structure by sixth grade students. *Educational Studies in Mathematics*, 166-181.
- Lane, C. 2010. *Case study: the effectiveness of virtual manipulatives in the teaching of primary mathematics*. Limerick: University of Limerick. (Dissertation – MEd).
- Limpopo Provincial Education Department. 2011. *Report on learner performance in Grades 3, 6 and 9*.
<http://policyresearch.limpopo.gov.za/bitstream/handle/123456789/787/Learner%20performance%20in%20Gr.%203%2C%206%20and%209.pdf?sequence=1> Date of access: 14 Jun. 2022.
- Lindqvist, G. 1995. *The aesthetics of play: a didactic study of play and culture in preschools*. Stockholm: Almqvist & Wiksell.
- Linn, M.C., Davis, E.A. & Bell, P. 2004. *Internet environments for science education*. London: Lawrence Erlbaum.

- MacDonald, B.L., Tofel-Grehl, C. & Searle, K.A. 2022. Play, problem-solving, STEM conceptions, and efficacy in STEM: an introduction to the STEM in early childhood education special issue. *Education Sciences*, 12(5):352.
- Machaba, M.M. 2013. *Teacher challenges in the teaching of Mathematics at Foundation Phase*. Pretoria: University of South Africa. (Thesis – PhD).
- Mackenzie, N. & Knipe, S. 2006. Research dilemmas: paradigms, methods and methodology. *Issues in Educational Research*, 16(2):193-205.
- Maree, K. & Van der Westhuizen, C. 2012. Planning a research proposal. In: Maree, K., ed. *First steps in research*. Pretoria: Van Schaik. pp. 24-45.
- Marshall, C. & Rossman, G.B. 2011. *Designing qualitative research*. 5th ed. Thousand Oaks, CA: Sage.
- Matlhware, J.M. & Erasmus, L.J. 2015. An investigation into the effective functioning of the Section 20 school funding system: the case of the Tshwane school districts. In Dichaba, M. & Nwaozuzu, D., eds. *Proceedings of the South Africa International Conference on Education*. Pretoria: African Academic Research Forum.
- McKim, C.A. 2017. The value of mixed methods research: a mixed methods study. *Journal of Mixed Methods Research*, 11(2):202-222.
- Melnikovas, A. 2018. Towards an explicit research methodology: adapting research onion model for futures studies. *Journal of Futures Studies*, 23(2):29-44.
- Merrill, C. & Daugherty, J. 2009. *The future of TE master's degrees: STEM*. Paper presented at the meeting of the International Technology Education Association, Louisville, KY.
<https://www.semanticscholar.org/paper/The-Future-of-TE-Masters-Degrees%3A-STEM-Merrill-Daugherty/f677ebb60bc7e0949bdd22fe916bb> Date of access: 15 Mar. 2021.
- Mohajan, H.K. 2017. Two criteria for good measurements in research: validity and reliability. *Economic Series*, 17(4):58-82.
- Moore, T.J., Johnson, C.C., Peters-Burton, E.E. & Guzey, S.S. 2015. The need for a STEM roadmap. In: Johnson, C.C., Peters-Burton, E.E. & Moore, T.J., eds. *STEM road map: a framework for integrated STEM education*. London: Routledge. pp. 3-12.
- Moses, E. & Van der Berg, S. 2017. Early learning = equality and jobs. *Mail & Guardian*, 29, 24-30 Mar.

- Mouton, J. 2011. *How to succeed in your master's and doctoral studies*. Pretoria: Van Schaik.
- Moyer, P.S. 2001. Are we having fun yet? How teachers use manipulatives to teach mathematics. *Educational Studies in Mathematics*, 47:175-197.
- Muijs, D. 2010. *Doing quantitative research in education with SPSS*. London: Sage.
- Mullis, I.V.S., Martin, M.O., Foy, P., Kelly, D.L. & Fishbein, B. 2020. *TIMSS 2019 international results in Mathematics and Science*. Chestnut Hill, PA: TIMSS & PIRLS International Study Center, Lynch School of Education and Human Development, Boston College and International Association for the Evaluation of Educational Achievement.
<https://www.iea.nl/sites/default/files/2020-12/TIMSS-2019-International-Results-in-Mathematics-and-Science.pdf> Date of access: 2 Jun. 2022.
- Mutanga, M.B. & Abayomi, A. 2022. Tweeting on COVID-19 pandemic in South Africa: LDA-based topic modelling approach. *African Journal of Science, Technology, Innovation and Development*, 14(1):163-172.
- National Education Association of the United States. 1894. *Report of the Committee of Ten on secondary school studies – with the reports of the conferences arranged by the committee*. New York, NY: American Book Company.
https://books.google.co.za/books?hl=en&lr=&id=1WYWAAAAIAAJ&oi=fnd&pg=PR1&ots=UxSCfRkZ7b&sig=AOxF24SquowbDCloAe0O54frMts&redir_esc=y#v=onepage&q&f=false Date of access: 15 Sept. 2021.
- Nchabeleng, E. 2021. *Department of Basic Education on school readiness for 2022; with Deputy Minister*. <https://pmg.org.za/committee-meeting/34064/> Date of access: 13 May. 2022.
- Newby, P. 2014. *Research methods for education*. 2nd ed. New York, NY: Routledge.
- Niss, M. 1992. Assessment in Mathematics education and its effects: an introduction. In: Niss, M., ed. *Investigations into assessment in Mathematics education: an ICMI study*. Dordrecht: Kluwer Academic Publishers. pp. 1-30.
- Noble, H. & Smith, J. 2015. Issues of validity and reliability in qualitative research. *Evidence-Based Nursing*, 18(2):34-35.
- Olympiou, G. & Zacharia, Z.C. 2011. Blending physical and virtual manipulatives: an effort to improve students' conceptual understanding through science laboratory experimentation. *Science Education*, 96(1):21-47.

Organisation for Economic Co-operation and Development (OECD). 2017. *PISA for development assessment and analytical framework: Reading, Mathematics and Science, preliminary version*. Paris: OECD.

Ostler, E. 2012. 21st-century STEM education: a tactical model for long-range success. *International Journal of Applied Science and Technology*, 2(1):28-33.

Perri 6 & Bellamy, C. 2012. *Principles of methodology: research design in social sciences*. London: Sage.

Piaget, J. 1952. Autobiography. In: Boring E., ed. *History of psychology in autobiography*. 4th ed. Worcester, MA: Clark University Press. pp. 59-79.

Piaget, J. 1971. *Biology and knowledge: an essay on the relations between organic regulations and cognitive processes*. Chicago, IL: University of Chicago Press.

Pistorova, S. & Slutsky, R. 2018. There is still nothing better than quality play experiences for young children's learning and development: building the foundation for inquiry in our educational practices. *Early Child Development and Care*, 188(5):495-507.

Plakitsi, K., 2013. Cultural-Historical Activity Theory (CHAT) Framework and Science Education in the Positivistic Tradition: Towards a New Methodology?. In: *Activity Theory in Formal and Informal Science Education*. Leiden: Brill. pp. 17-26.

Pramling Samuelsson, I. & Johansson, E. 2006. Play and learning — inseparable dimensions in preschool practice. *Early Child Development and Care*, 176(1):47-65.

Reddy, V., Winnaar, L., Juan, A., Arends, F., Harvey, J., Hannan, S., Namome, C. & Zulu N. 2022. *TIMSS 2019: highlights of South African Grade 5 results in Mathematics and Science – achievements and achievement gaps*.
https://www.education.gov.za/Portals/0/Documents/Reports/TIMSS2019/TIMSS2019_Grade%2005_Final%20Report.pdf?ver=2020-12-08-120744-547 Date of access: 6 Jun. 2022.

Reddy, V., Winnaar, L., Juan, A., Arends, F., Harvey, J., Hannan, S., Isdale, K., Arends, F. & Juan, A. 2022. *The South African TIMSS 2019 Grade 5 results: building achievement and bridging achievement gaps*. <https://www.timss-sa.org/wp-content/uploads/2022/03/TIMSS-2019-Grade-5-National-report-FINAL.pdf> Date of access: 23 Jun. 2022.

Rollnick, M. & Mavhunga, E. 2014. PCK of teaching electrochemistry in chemistry teachers: a case in Johannesburg, Gauteng Province, South Africa. *Educación Química*, 25(3):354-362.

Roth, W.M. & Lee, Y.J. 2007. "Vygotsky's neglected legacy": cultural-historical activity theory. *Review of Educational Research*, 77(2):186-232.

Rust, A.L. 1999. *A study of the benefits of math manipulatives versus standard curriculum in the comprehension of mathematical concepts*. Knoxville, TN: Johnson Bible College. (Dissertation – MEd).

Sarama, J. & Clements, D.H. 2016. Physical and virtual manipulatives: what is "concrete"? In: Moyer-Packenham, P.S., ed. *International perspectives on teaching and learning mathematics with virtual manipulatives*. Cham: Springer. pp. 71-93.

Saunders, M., Lewis, P. & Thornhill, A. 2009. Understanding research philosophies and approaches. In: Saunders, M., Lewis, P. & Thornhill, A. eds. *Research methods for business students*. 5th ed. Harlow: Pearson Education. pp. 106-135.

Savides, M. 2017. South African schools have 5,139 teachers who are unqualified or under-qualified. *Times Live*, 6 Jun. <https://www.timeslive.co.za/news/south-africa/2017-06-06-south-african-schools-have-5139-teachers-who-are-unqualified-or-under-qualified/> Date of access: 23 May. 2022.

Sheldon, M. 2014. *Life Skills in the Foundation Phase: a multiple case study into how Life Skills is enacted in two Grade 3 classrooms in Johannesburg*. Johannesburg: University of the Witwatersrand. (Dissertation – MEd).

Shulman, L.S. 1986. Those who understand: knowledge growth in teaching. *Educational Researcher*, 15(2):4-14.

Siekmann, G. & Korbel, P. 2016. *Defining "STEM" skills: review and synthesis of the literature*. Adelaide: National Centre for Vocational Education Research.

Simpson, S. 2022. Revealed: these are the provinces with the most unqualified teachers. *The South African*, 22 Mar. <https://www.thesouthafrican.com/news/south-africa/breaking-revealed-these-are-the-provinces-with-the-most-unqualified-teachers/> Date of access: 6 Jun. 2022.

Soudien, C., Reddy, V. & Harvey, J. 2022. The impact of Covid-19 on a fragile education system: the case of South Africa. In: Reimers, F.M., ed. *Primary and secondary education during Covid-19*. Cham: Springer. pp. 303-325.

South African Qualification Authority. 2017. *The role of the national qualifications framework (NQF) and the national learners' records database (NLRD) in showing trends in the education*

and training sector. https://www.saga.org.za/sites/default/files/2019-11/Fact%20Sheet%20SAQA-FPI_0.pdf Date of access: 23 May. 2022.

South African Schools Act 84 of 1996.

Sowell, E.J. 1989. Effects of manipulative materials in mathematics instruction. *Journal for Research in Mathematics Education*, 20(5):498-505.

Spaull, N. & Kotze, J. 2015. Starting behind and staying behind in South Africa: a case of insurmountable learning deficits in mathematics. *International Journal of Educational Development*, 41:13-24.

Spaull, N. 2020. Covid-19 and schooling in South Africa: who should go back to school first? *Prospects*. <https://doi.org/10.1007/s11125-020-09470-5>

Srikoom, W., Faikhamta, C. & Hanuscin, D. 2018. Dimensions of effective STEM integrated teaching practice. *K-12 STEM Education*, 4(2):313-330.

Sternberg, R.J. 2006. The nature of creativity. *Creativity Research Journal*, 18(1):87-98.

Steyn, H.J. & Wolhuter, C.C. 2021. The nature of the education system and compelling societal trends of the early 21st century. In: Wolhuter, C.C. & Steyn, H.J., eds. *World education system: entering the 21st century*. Noordbrug: Keurkopie. pp. 1-22.

Steyn, H.J. 2021. Considering critical issues in education systems: core characteristics to always bear in mind. In: Wolhuter, C.C & Steyn, H.J., eds. *Critical issues in education systems: comparative-international perspectives*. Noordbrug: Keurkopie. pp. 32-68.

Steyn, H.J., Steyn, S.C., De Waal, E.A.S. & Wolhuter, C.C. 2011. *South African education system*. Keurkopie: Potchefstroom.

Stylianidou, F., Glauert, E., Rossis, D. & Havu-Nuutinen, S. 2016. "Creative Little Scientists" project: mapping and comparative assessment of early years Science education policy and practice. In: Papadouris, N., Hadjigeorgiou, A. & Constantinou, C.P., eds. *Insights from research in science teaching and learning*. Cham: Springer. pp. 201-220.

Sullivan, A., Strawhacker, A. & Bers, M.U. 2017. Dancing, drawing, and dramatic robots: integrating robotics and the arts to teach foundational STEAM concepts to young children. In: Khine, M.S., eds. *Robotics in STEM education: redesigning the learning experience*. Cham: Springer. pp. 231-260.

- Tashakkori, A. & Teddlie, C. 2010. Putting the human back in “human research methodology”: the researcher in mixed methods research. *Journal of Mixed Methods Research*, 4(4):271-277.
- Timæus, I.M., Simelane, S. & Letsoalo, T. 2013. Poverty, race, and children’s progress at school in South Africa. *Journal of Development Studies*, 49(2):270-284.
- Valsiner, J. 2000. Data as representations: contextualizing qualitative and quantitative research strategies. *Social Science Information*, 39(1):99-113.
- Van den Akker, J. 2003. Curriculum perspectives: an introduction. In: Van den Akker, J., Kuiper, W. & Hameyer, U., eds. *Curriculum landscapes and trends*. Dordrecht: Springer. pp. 1-10.
- Van den Akker, J. 2013. Curricular development research as a specimen of educational design research. In: Plomp, T. & Nieveen, N., eds. *Educational design research*. Enschede: Netherlands Institute for Curriculum Development. pp. 52-71.
- Van der Walt, M.A. 2020. *Developing pedagogical content knowledge for teaching science to young learners*. Potchefstroom: North-West University. (Thesis – PhD).
- Van Niekerk, E.F. 1997. *Die ontstaan, verloop en toekoms van Christelik-nasionale onderwys in Suid-Afrika*. Pretoria: University of South Africa. (Dissertation – MEd).
- Van Schalkwyk, C., McConnachie, C. & Kota, Z. 2022. “Tough love” budget cuts are toughest on the poorest learners. *Mail & Guardian*, 29 Mar. <https://mg.co.za/opinion/2022-03-29-tough-love-budget-cuts-are-toughest-on-the-poorest-learners/> Date of access: 13 May 2022.
- Venketsamy, R. 2022. Teachers’ needs for instructional support at early number sense: analysis in terms of (lens) the concerned based model for teacher development. *Journal for the Education of Gifted Young Scientists*, 10(1):23-35.
- Vos, D., De Beer, Z.L., Nhlapo V.A. & Kumalo, J.B. 2021. The South African system. In: Wolhuter, C.C. & Steyn, H.J., eds. *World education system: entering the 21st century*. Noordbrug: Keurkopie. pp. 44-74.
- Vygotsky, L.S. 1980. *Mind in society: the development of higher psychological processes*. Cambridge: Harvard University Press.
- Wang, H.H., Charoenmuang, M., Knobloch, N.A. & Tormoehlen, R.L. 2020. Defining interdisciplinary collaboration based on high school teachers’ beliefs and practices of STEM integration using a complex designed system. *International Journal of STEM Education*, 7(1):1-17.

Waring, M. 2017. Finding your theoretical position. In: Coe, R.J., Waring, M., Hedges, L.V. & Arthur, J., eds. *Research methods & methodologies in education*. 2nd ed. London: Sage. pp. 15-22.

Willemse, K., Venketsamy, T. & Swanepoel, N. 2022. Support teachers need to assist learners experiencing mathematical learning difficulties. In: Langenhoven, K.R. & Stevenson-Milln, C.H., eds. *Book of Proceedings of the 30th Annual Conference of the Southern African Association for Research in Mathematics, Science and Technology Education*. Western Cape: SAARMSTE. pp. 179-190.

Yilmaz, K. 2013. Comparison of quantitative and qualitative research traditions: epistemological, theoretical, and methodological differences. *European Journal of Education*, 48(2):311-325.

Zacharia, Z.C. & Constantinou, C.P. 2008. Comparing the influence of physical and virtual manipulatives in the context of the Physics by inquiry curriculum: the case of undergraduate students' conceptual understanding of heat and temperature. *American Journal of Physics*, 76(4):425-430.

Zhong, B., Liu, X., Xia, L. & Sun, W. 2022. A proposed taxonomy of teaching models in STEM education: robotics as an example. *Sage Open*, 12(2):1-15.

Zimmerman, A.S. 2017. The STEAM inherent in STEM: a mathematical example. *The STEAM Journal*, 3(1):13.

ADDENDUM A – CREATIVE LITTLE SCIENTISTS QUESTIONNAIRE (CREATIVE LITTLE SCIENTISTS, 2012A:153-172).



D3.3 Report on First Survey of School Practice

APPENDIX 2: FINAL QUESTIONNAIRE

1. 'Creative Little Scientists' Teacher Survey

Thank you for agreeing to take part in the *Creative Little Scientists* online teacher survey. We hope that it will be an interesting experience for you. The aim of the work is to contribute to a better understanding across Europe of the common ground that science and mathematics education can share with the development of creativity in pre-school and first years of compulsory school (up to the age of eight). In this survey we aim to explore existing practices in pre-school and first years of compulsory school science and mathematics across nine European countries (Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania, and the UK). We are seeking to identify opportunities and challenges for the development of creative skills within these areas of the curriculum.

There are 44 questions organized in 7 sections:

- Background Information – About your School
- Background Information – About You
- Your Knowledge, and Skills and Confidence in Teaching Science and Mathematics
- Your Views about and Approaches in Teaching Science
- Your Views about and Approaches in Assessing Science Learning
- School Science and Mathematics Resources and Your Use of Them
- Thanking You and Further Communication

Almost all questions are multiple-choice questions and require you to select one or more answers as appropriate. Three questions will give you the opportunity to give your views on how creativity can be fostered as part of science teaching and another two questions will ask you to reflect about the differences between science and mathematics teaching in pre-school and first years of compulsory school. The questionnaire addresses teachers practicing across a wide age range, so you are kindly asked to interpret the wording of the questions according to the age phase you are teaching.

All your responses will be treated in the strictest confidence (according to the EC directive 95/46/EC) and will only be used for research purposes. All data gathered during the project will be stored in a secure location accessible only to the researchers.

Lexicon

Pre-school: Provision for young children prior to beginning in compulsory education. This can span education and care.

Early years: Birth to 8 years of age incorporating kindergarten, nursery, pre-school, elementary school, primary school.



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Page 153 of 210



2. Background Information – About your School

1. *School Details

- *School name:
- Address 1:
- Address 2:
- *City/Town:
- State/Province:
- *ZIP/Postal Code:
- *Country:

2. Which of the following best describes the community in which this school is located?

- a. A <village, hamlet or rural area> (fewer than 3 000 people)
- b. A <small town> (3 000 to about 15 000 people)
- c. A <town> (15 000 to about 100 000 people)
- d. A <city> (100 000 to about 1 000 000 people)
- e. A large <city> with over 1 000 000 people

3. Approximately how many children are in your school?

- a. < 50
- b. 50-100
- c. 101-150
- d. 151-200
- e. 201-500
- f. 501-750
- g. 750+

4. For which age range of children does your school provide education and/or care?

5. Would you characterize your school as? (Please select all that apply)

- a. Fee paying
- b. Non-fee paying
- c. Public / State
- d. Private
- e. Run by Local Educational Authority
- f. Other school characteristics. Please specify:





3. Background Information – About You

6. Are you male or female?

- a. Male
- b. Female

7. Your Age range:

- a. Under 25
- b. 25-29
- c. 30-39
- d. 40-49
- e. 50-59
- f. 60+

8. What is the highest level of formal education that you have completed?

- a. Finished Upper Secondary Education (Vocational)
- b. Finished Upper Secondary Education (General)
- c. Finished Post-Secondary Non-Tertiary Education (Vocational)
- d. Finished Post-Secondary Non-Tertiary Education (General)
- e. Finished Bachelor Level Education or Equivalent
- f. Finished higher than Bachelor Level Education or Equivalent – e.g. Masters Level Education, Doctoral Level Education, or equivalent. Please specify

9. What is/are the main subject(s) of your highest educational qualification (if appropriate)?

10. Please list any other qualifications you have, including professional qualifications.

a.
b.
c.
d.
e.

11. Are you certified to teach?

- a. Yes
- b. No





12. By the end of this school year, how long have you been working as a teacher?

- a. Fewer than 5 years
- b. 5-10 years
- c. 11-20 years
- d. More than 20 years

13. Please describe your current position in the school.

14. Which age groups have you taught in the last 3 school years and are **LIKELY** to teach next school year? (Select all that apply).

	2009-10	2010-11	2011-12	2012-13
a. Younger than 3 years				
b. 3-4 years				
c. 4-5 years				
d. 5-6 years				
e. 6-7 years				
f. 7-8 years				
g. Older than 8 years				
h. N/A				
i. If you have selected more than one age group for any school year, please specify if you taught /are likely to teach these age groups concurrently, or in separate classrooms:				

15. Approximately how many children are in your classroom?

- a. Fewer than 10
- b. 10-15
- c. 16-20
- d. 21-25
- e. 26-30
- f. More than 30





4. Your Knowledge, Skills and Confidence in Teaching Science and Mathematics

16. What is the highest formal education level in which you studied SCIENCE?

- a. Lower Secondary Education
- b. Upper Secondary Education (Vocational)
- c. Upper Secondary Education Secondary Education (General)
- d. Post-Secondary Non-Tertiary Education (Vocational)
- e. Post-Secondary Non-Tertiary Education (General)
- f. Bachelor Level Education
- g. Masters Level Education
- h. Other (Please specify):

17. What is the highest formal education level in which you studied MATHEMATICS?

- a. Lower Secondary Education
- b. Upper Secondary Education (Vocational)
- c. Upper Secondary Education Secondary Education (General)
- d. Post-Secondary Non-Tertiary Education (Vocational)
- e. Post-Secondary Non-Tertiary Education (General)
- f. Bachelor Level Education
- g. Masters Level Education
- h. Other (Please specify):

18. As part of your post-compulsory education and/or initial teacher training, to what extent did you study the following areas?

	Not at all	Overview or introduction to topic	It was an area of emphasis
a. Mathematics			
b. Science			
c. Environmental or Earth Sciences			
d. ICT			
e. Pedagogy			
f. Developmental Psychology			
g. Children's Development of Creativity			
h. Creative Teaching Approaches			



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19. During the last 18 months, did you have the opportunity to participate in any of the following kinds of professional development activities and if so, what was the impact of these activities on your teaching of SCIENCE or MATHEMATICS respectively?

	No impact	A small impact	A moderate impact	A large impact	N/A
a. Courses/workshops on Science subject matter or methods					
b. Courses/workshops on Mathematics subject matter or methods					
c. Science education conferences or seminars (where teachers and/or researchers present their research results and discuss educational problems)					
d. Mathematics education conferences or seminars (where teachers and/or researchers present their research results and discuss educational problems)					
e. Science teaching observations in other schools					
f. Mathematics teaching observations in other schools					
g. Participation in a network of teachers formed specifically for the professional development of teachers in Science					
h. Participation in a network of teachers formed specifically for the professional development of teachers in Mathematics					
i. Individual or collaborative research on a Science topic of interest to you professionally					
j. Individual or collaborative research on a Mathematics topic of interest to you professionally					
k. Mentoring and/or peer observation and coaching of Science teaching, as part of a formal school arrangement					
l. Mentoring and/or peer observation and coaching of Mathematics teaching, as part of a formal school arrangement					
m. Reading Science professional literature (e.g. journals, evidence-based papers, thesis papers)					
n. Reading Mathematics professional literature (e.g. journals, evidence-based papers, thesis papers)					
o. Engaging in informal dialogue with your colleagues on how to improve your science teaching					
p. Engaging in informal dialogue with your colleagues on how to improve your mathematics teaching					
q. Other kind of professional development activity that had an impact on your teaching of Science or Mathematics (Please specify)					



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20. How would you rate your confidence in the following?

	1 (Very low)	2	3	4 (Very high)
a. Your knowledge and understanding of important scientific ideas.				
b. Your knowledge and understanding of important scientific processes.				
c. Your competencies necessary to carry out scientific inquiry.				
d. Your understanding about scientific inquiry (e.g. how science and scientists work).				
e. Your general pedagogic knowledge.				
f. Your knowledge of science pedagogy/didactics.				
g. Your knowledge of mathematics pedagogy/didactics.				
h. Your science teaching.				
i. Your mathematics teaching.				
j. Assessing children in science.				
k. Assessing children in mathematics.				
l. Your ICT skills.				



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5. Your Views about and Approaches in Teaching Science

21. Approximately how much time do you have planned for teaching SCIENCE and MATHEMATICS per week? (Please estimate).

	Science	Mathematics
a. Less than an hour		
b. 1-2 h		
c. 3-4 h		
d. More than 4 h		
e. N/A (Please explain)		

22. List up to five (5) SCIENCE topics/areas/themes that you have addressed in your teaching this school year.

-
-
-
-
-

23. Please indicate your views on the importance of the following purposes of school SCIENCE in COMPULSORY EDUCATION (5 to 16-year-olds).

	1 (Not important)	2	3	4 (Very important)
a. To provide a foundational education for future scientists and engineers				
b. To develop socially and environmentally aware and responsible citizens				
c. To enrich the understanding and interaction with phenomena in nature and technology				
d. To develop more innovative thinkers				
e. To develop positive attitudes to science				
f. To develop important attitudes and dispositions as a foundation for future learning				



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24. Now focusing on the AGE GROUP(s) YOU TEACH, please indicate how often you foster the development of the following SCIENCE learning outcomes.

Please interpret the following in ways appropriate to the AGE PHASE YOU TEACH.

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4	N/A
a. To know and understand the important scientific ideas (facts, concepts, laws and theories).					
b. To understand that scientists describe the investigations in ways that enable others to repeat the investigations.					
c. To be able to ask a question about objects, organisms, and events in the environment.					
d. To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.					
e. To know and understand important scientific processes.					
f. To be able to communicate investigations and explanations.					
g. To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.					
h. To have positive attitudes to science learning.					
i. To be interested in science.					
j. To be able to plan and conduct a simple investigation.					
k. To have positive attitudes to learning.					
l. To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).					
m. To be able to collaborate with other children					



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25. How often do you use the following learning/teaching contexts and approaches in your SCIENCE teaching?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4
a. Open/unstructured play				
b. Role/Pretend play				
c. Drama				
d. Teaching science from stories				
e. Using history to teach science (e.g. transport, the work of scientists)				
f. Working in small groups				
g. Physical exploration of materials				
h. Using outdoor learning activities				
i. Taking children on field trips and/or visits to science museums and industry				
j. Integrating science with other curricular areas				
k. Building on children's prior experiences				
l. Fostering collaboration				
m. Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical				
n. Encouraging problem finding – e.g. children asking questions				
o. Encouraging problem solving – e.g. children solving practical tasks				
p. Encouraging children to try out their own ideas in investigations				
q. Fostering classroom discussion and evaluation of alternative ideas				
r. Fostering imagination				
s. Relating science to everyday life				
t. Using questioning as a tool in science teaching				
u. Using digital technologies with children for science teaching and learning				
v. Fostering autonomous learning				



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26. Which of the contexts mentioned in question 25 do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY?

	Choose up to 3 answers
a. Open/unstructured play	
b. Role/Pretend play	
c. Drama	
d. Teaching science from stories	
e. Using history to teach science (e.g. transport, the work of scientists)	
f. Working in small groups	
g. Physical exploration of materials	
h. Using outdoor learning activities	
i. Taking children on field trips and/or visits to science museums and industry	
j. Integrating science with other curricular areas	
k. Please mention any other context you think as contributing significantly to the development of children's creativity and justify your selection(s):	

27. Which of the teaching approaches mentioned in question 25 do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY?

	Choose up to 3 answers
a. Building on children's prior experiences	
b. Fostering collaboration	
c. Encouraging different ways of recording and expressing ideas – oral, visual, digital, practical	
d. Encouraging problem finding – e.g. children asking questions	
e. Encouraging problem solving – e.g. children solving practical tasks	
f. Encouraging children to try out their own ideas in investigations	
g. Fostering classroom discussion and evaluation of alternative ideas	
h. Fostering imagination	
i. Relating science to everyday life	
j. Using questioning as a tool in science teaching	
k. Using digital technologies with children for science teaching and learning	
l. Fostering autonomous learning	
m. Please mention any other teaching approach you think as contributing significantly to the development of children's creativity and justify your selection(s):	





28. Question 25 referred to the contexts and approaches used by you in SCIENCE teaching. Please reflect and briefly describe in what ways, if any, these contexts and approaches might differ in the case of MATHEMATICS.

29. How often do you encourage children to undertake the following activities in SCIENCE?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4
a. Observe natural phenomena such as the weather or a plant growing and describe what they see.				
b. Ask questions about objects, organisms, and events in the environment.				
c. Design or plan simple investigations or projects.				
d. Conduct simple investigations or projects				
e. Employ simple equipment and tools to gather data and extend to the senses.				
f. Use data to construct reasonable explanations.				
g. Communicate the results of their investigations and explanations.				

30. Which of the SCIENCE activities mentioned in question 29 do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY?

	Choose up to 3 answers
a. Observe natural phenomena such as the weather or a plant growing and describe what they see.	
b. Ask questions about objects, organisms, and events in the environment.	
c. Design or plan simple investigations or projects.	
d. Conduct simple investigations or projects	
e. Employ simple equipment and tools to gather data and extend to the senses.	
f. Use data to construct reasonable explanations.	
g. Communicate the results of their investigations and explanations.	
h. Please mention any other activity you think as contributing significantly to the development of children's creativity and justify your selection(s):	





The following table shows some essential features of INQUIRY learning in SCIENCE education and their possible variations in the classroom.

	A (Open)	B (Guided)	C (Structured)
a. QUESTION: Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher, materials or other source	Child is given a scientifically oriented question by the teacher, materials or other source
b. EVIDENCE: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source
c. ANALYSE: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher, materials or other source	Child is told how to analyse evidence provided by the teacher, materials or other source
d. EXPLAIN: Children formulate explanation based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence
e. CONNECT: Children connect explanations to scientific knowledge	Child independently finds and examines other resources and forms links to scientific knowledge	Child is directed to other resources and shown how to form links to scientific knowledge	Child is given other resources and shown the links with scientific knowledge
f. COMMUNICATE: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source
g. REFLECT: Children reflect on the inquiry process and their learning	Child decides independently how to structure reflection on the inquiry process and his/her learning	Child is given broad guidelines to structure reflection on the inquiry process and his/her learning by the teacher, materials or other source	Child is given a structured framework for reflection by the teacher, materials or other source





31. For each of the INQUIRY features please indicate the variation (A, B or C) from the table above that MOSTLY characterizes your approach in the SCIENCE classroom.

	A (Open)	B (Guided)	C (Structured)	N/A
a. QUESTION: Children investigate scientifically oriented question				
b. EVIDENCE: Children give priority to evidence				
c. ANALYSE: Children analyse evidence				
d. EXPLAIN: Children formulate explanations based on evidence				
e. CONNECT: Children connect explanations to scientific knowledge				
f. COMMUNICATE: Children communicate and justify explanation				
g. REFLECT: Children reflect on the inquiry process and their learning				

h. If you have selected N/A, please explain:

32. How strongly do you agree or disagree with each of the following statements about the role of teacher in fostering INQUIRY skills?

	1 (Strongly Disagree)	2	3	4 (Strongly Agree)
a. Teachers should demonstrate first the correct way to solve a problem				
b. Teachers should give children ample time to work out their own solutions to problems before showing them how they are solved				
c. Teachers should facilitate children's own inquiry				
d. Teachers should allow children to find solutions to problems on their own				



6. Your Views about and Approaches in Assessing Science

Learning

33. Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of children's ASSESSMENT in SCIENCE education.

To assess the development of children's:

	1 (Not important)	2	3	4 (Very important)
a. Knowledge and understanding of scientific ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of scientific processes				
c. Competencies necessary to carry out scientific inquiry				
d. Understandings about scientific inquiry (e.g. how science and scientists work)				
e. Positive attitudes and increase of interest in science				
f. Positive attitudes and increase of interest in learning science				

34. How often do you assess your pupils in SCIENCE in the following ways?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4
a. Using checklists to record observations of children				
b. During classroom interaction				
c. Evaluating children's pictures, graphs etc which show their scientific reasoning				
d. Evaluating children's relevant gestures or physical activity				
e. Marking their homework				
f. Using authentic problem-based tasks				
g. Asking each child to reflect on their own learning and progress				
h. Using closed question tests				
i. Using open question tests				
j. Using questions in context				
k. Using portfolios (collection of evidence of children's work and progress)				
l. Children correcting each other's work and giving each other feedback				



35. How often do you reward/praise the following characteristics in your pupils in SCIENCE?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4
a. Sense of initiative				
b. Motivation				
c. Ability to come up with something new				
d. Ability to connect what they have learnt during your lessons with topics in other subjects				
e. Imagination				
f. Curiosity				
g. Ability to work together				
h. Thinking skills				

36. How often do you use ASSESSMENTS of children in SCIENCE for the following purposes?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4
a. To identify areas for improvement in your science teaching				
b. To identify aspects of the science curriculum that could be improved				
c. To identify ways to improve child science learning				
d. To monitor regularly individual children's or cohorts of children's progress towards a set of desirable science learning outcomes				
e. To inform parents of their child's progress in science				
f. To help group children for science instruction purposes				
g. To monitor year-to-year child progress in science				
h. To provide feedback to children about their progress in science				
i. To set targets with children for their own development in science				

37. Questions 34-36 referred to the approaches used by you in the assessment of SCIENCE learning. Please reflect and briefly describe in what ways, if any, these approaches might differ in the case of MATHEMATICS.





7. School Science and Mathematics Resources and Your Use of Them

38. How well resourced do you feel your school is for the teaching of SCIENCE in terms of the following?

	1 (Not at all)	2	3	4 (Very Well)
a. Instructional materials (e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				

39. How well resourced do you feel your school is for the teaching of MATHEMATICS in terms of the following?

	1 (Not at all)	2	3	4 (Very Well)
a. Instructional materials (e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. sorting activity games, rulers)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				



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40. How often do you use the following resources in your SCIENCE and MATHEMATICS teaching?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4	N/A
a. Student Textbooks					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. Resources downloaded from the Internet					
e. Audio-visual resources					
f. Relevant library materials (e.g. story books)					
g. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					
h. Computers					
i. Digital technologies (e.g. interactive whiteboard)					
j. ICT resources (e.g. website, digital game)					
k. Relevant media materials (e.g. newspapers, magazines)					

l. Other resources that you often use in your Science and Mathematics teaching:





41. How often do you consult the following resources to inform your **SCIENCE** and **MATHEMATICS** teaching preparation?

	Never - 1	Rarely - 2	Quite often - 3	Very often - 4	N/A
a. Student textbook					
b. Teacher textbook guide					
c. Online textbook resources (incl. publishers' websites)					
d. School curriculum					
e. National curriculum					
f. National teacher curriculum guide					
g. National education agency website					
h. Teacher professional association documentation or website					
i. School assessment guidelines					
j. National assessment guidelines					
k. Other resources that you often use to inform your Science and Mathematics teaching preparation:					





8. Thanking You and Further Communication

We would like to thank you for spending time and effort to participate in the 'Creative Little Scientists' project survey.

Your contribution is greatly appreciated.

42. Any other comments you may have either about the issues or in response to the questionnaire are welcome feedback to our research.

e.g. Has the questionnaire prompted thought about issues you have not have had considered before? Were there particular questions you felt you could not answer and why?

43. Please indicate whether you wish to be contacted by the project for any of the following reasons:

	Yes	No
a. Receive acknowledgment of your participation in the 'Creative Little Scientists' project survey		
b. Clarify/Discuss further responses you gave in the survey		
c. Participate in the second phase of the research, collaborating with researchers through classroom observations and interviews (January-April 2013).		
d. Receive electronically the report that will be produced in English on early years science practices and their implications for children's creativity, which will include a set of exemplary case studies illustrating the variety of approaches observed throughout the nine European countries participating in the project.		
e. Receive a publication (in English) containing exemplary teacher training materials, which will be selected on the basis of good practices identified in the case studies as well as being consistent with the guidelines and curricula for teacher training produced by the project.		

44. If you have indicated positively in any of the above aspects of the question above, please do provide us with your contact details.

First Name:

Surname:

Contact Email Address:

Contact Phone Number:



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ADDENDUM B – ADAPTED CREATIVE LITTLE SCIENTISTS

QUESTIONNAIRE

The purpose of this questionnaire is to gather data regarding the perceptions of teachers with regards to STEM education in Grade R-3. The data collected below is for the completion of the doctorate degree in education titled: Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3. This questionnaire has been adapted from the Creative Little Scientists Consortium (2012: 154-171).

a) Background information

1. School details

Name of school:		City/Town:	

2. Which of the following best describes the community in which this school is located?

A village, rural area, farm area (fewer than 3000 people)	
A small town (3000 to about 15 000 people)	
A town (15 000 to about 100 000 people)	
A city (100 000 to about 1 000 000 people)	

3. Approximately how many children are in this school?

<50		50-100		101-150		151-200	
201-500		501-750		751-1000		1000+	

4. Gender of the teacher:

Male		Female		Other	

5. Age of the teacher:

6. Highest level of formal education

7. Grade you are currently teaching

R		1		2		3	

8. How long have you been teaching (this school and previous schools):

9. Approximately how many children are in your class?

Less than 10		10-15		16-20		21-25	
26-30		31-35		36-40		40+	

b) Your approach and views about teaching SCIENCES (Science and Mathematics)

10. Approximately how much time do you have planned for teaching Science and Mathematics per week?

	Science	Mathematics
a. Less than an hour		
b. 1-2 hours		
c. 3-4 hours		
d. More than 4 hours		
e. N/A (please explain)		

11. List up to five SCIENCE and MATHEMATICS topics you have addressed in your teaching this school year:

	Science	Mathematics
a.		
b.		
c.		
d.		
e.		

12. Please indicate your view on the importance of the following purpose of school SCIENCES (Science and Mathematics) in compulsory education (Grade R-12).

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. To provide a foundational education for future scientists and engineers				
b. To develop socially and environmentally aware and responsible citizens				
c. To enrich the understanding and interaction with phenomena in nature and technology				
d. To develop more innovative thinkers				

e. To develop positive attitudes to sciences				
f. To develop important attitudes and dispositions as a foundation for future learning				

13. Please indicate how often you foster the development of the following SCIENCE learning outcomes

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To know and understand the important scientific ideas (facts, concepts, laws and theories)				
b. To understand that scientists describe the investigations in ways that enable others to repeat the investigations.				
c. To be able to ask a question about objects, organisms, and events in the environment.				
d. To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.				
e. To know and understand important scientific processes.				
f. To be able to communicate investigations and explanations				
g. To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.				
h. To have positive attitudes to science learning.				
i. To be interested in science.				
j. To be able to plan and conduct a simple investigation.				
k. To have positive attitudes to learning.				
l. To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).				
m. To be able to collaborate with other children				

14. Please indicate how often you foster the development of the following MATHEMATICS learning outcomes

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)

a. To know and understand the important mathematics ideas (facts, concepts, laws and theories)				
b. To understand that mathematicians describe the mathematics problems in ways that enable others to repeat the process.				
c. To be able to ask a question about objects and events in mathematics content.				
d. To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.				
e. To know and understand important mathematic processes.				
f. To be able to communicate investigations and explanations				
g. To understand that mathematic problem solving involve asking and answering a question and comparing the answer with what mathematicians already know about the world.				
h. To have positive attitudes to mathematics learning.				
i. To be interested in mathematics.				
j. To be able to plan and conduct a simple investigation.				
k. To have positive attitudes to learning.				
l. To understand that mathematicians develop explanations using observations (evidence) and what they already know about the world (mathematic knowledge).				
m. To be able to collaborate with other children				

15. How often do you use the following learning/teaching contexts and approaches in your **SCIENCE teaching?**

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Open/unstructured play				
b. Role/Pretend play				
c. Drama				
d. Teaching science from stories				
e. Using history to teach science (e.g. transport, the work of scientists)				
f. Working in small groups				
g. Physical exploration of materials				

h. Using outdoor learning activities				
i. Taking children on field trips and/or visits to science museums and industry				
j. Integrating science with other curricular areas				
k. Building on children's prior experiences				
l. Encouraging different ways of recording and expressing ideas –oral, visual, digital, practical				
m. Encouraging problem finding –e.g. children asking questions				
n. Encouraging problem solving –e.g. children solving practical tasks				
o. Encouraging children to try out their own ideas in investigations				
p. Fostering classroom discussion and evaluation of alternative ideas				
q. Fostering imagination				
r. Relating science to everyday life				
s. Using questioning as a tool in science teaching				
t. Using digital technologies with children for science teaching and learning				
u. Fostering autonomous learning				

16. How often do you use the following learning/teaching contexts and approaches in your MATHEMATICS teaching?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Open/unstructured play				
b. Role/Pretend play				
c. Drama				
d. Teaching mathematics from stories				
e. Using history to teach mathematics (e.g. using Pythagoras and solving everyday construction problems)				
f. Working in small groups				
g. Physical exploration of materials				
h. Using outdoor learning activities				
i. Taking children on trips and/or visits to computer labs to work with mathematics software				
j. Integrating mathematics with other curricular areas				

k. Building on children's prior experiences				
l. Encouraging different ways of recording and expressing ideas –oral, visual, digital, practical				
m. Encouraging problem finding –e.g. children asking questions				
n. Encouraging problem solving –e.g. children solving practical tasks				
o. Encouraging children to try out their own ideas in investigations				
p. Fostering classroom discussion and evaluation of alternative ideas				
q. Fostering imagination				
r. Relating mathematics to everyday life				
s. Using questioning as a tool in mathematics teaching				
t. Using digital technologies with children for mathematics teaching and learning				
u. Fostering autonomous learning				

17. How often do you encourage children to undertake the following activities in SCIENCE?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe natural phenomena such as the weather or a plant growing and describe what they see.				
b. Ask questions about objects, organisms, and events in the environment				
c. Design or plan simple investigations or projects				
d. Conduct simple investigations or projects				
e. Employ simple equipment and tools to gather data and extend to the senses.				
f. Use data to construct reasonable explanations.				
g. Communicate the results of their investigations and explanations.				

18. How often do you encourage children to undertake the following activities in MATHEMATICS?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe phenomena using tables and formulas.				

b. Ask questions about objects and events about mathematic content in real life situations.				
c. Design or plan simple investigations or projects				
d. Conduct simple investigations or projects				
e. Employ simple equipment and tools to gather data and extend to the senses.				
f. Use data to construct reasonable explanations.				
g. Communicate the results of their investigations and explanations.				

19. For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the SCIENCE classroom. (Please indicate your choice on the block with the description)

	A (Open)	B (Guided)	C (Structured)	N/A
a. QUESTION: Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher, materials or other source	Child is given a scientifically oriented question by the teacher, materials or other source	
b. EVIDENCE: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source	
c. ANALYSE: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher, materials or other source	Child is told how to analyse evidence provided by the teacher, materials or other source	
d. EXPLAIN: Children formulate explanations based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence	

e. CONNECT: Children connect explanations to scientific knowledge	Child independently finds and examines other resources and forms links to scientific knowledge	Child is directed to other resources and shown how to form links to scientific knowledge	Child is given other resources and shown the links with scientific knowledge	
f. COMMUNICATE: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source	
g. REFLECT: Children reflect on the inquiry process and their learning	Child decides independently how to structure reflection on the inquiry process and his/her learning	Child is given broad guidelines to structure reflection on the inquiry process and his/her learning by the teacher, materials or other source	Child is given a structured framework for reflection by the teacher, materials or other source	
h. If you have selected N/A, Please explain:				

20. For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the MATHEMATICS classroom. (Please indicate your choice on the block with the description)

	A (Open)	B (Guided)	C (Structured)	N/A
a. QUESTION: Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher,	Child is given a scientifically oriented question by the teacher, materials or other source	

		materials or other source		
b. EVIDENCE: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source	
c. ANALYSE: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher, materials or other source	Child is told how to analyse evidence provided by the teacher, materials or other source	
d. EXPLAIN: Children formulate explanations based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence	
e. CONNECT: Children connect explanations to scientific knowledge	Child independently finds and examines other resources and forms links to scientific knowledge	Child is directed to other resources and shown how to form links to scientific knowledge	Child is given other resources and shown the links with scientific knowledge	
f. COMMUNICATE: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source	
g. REFLECT: Children reflect on the inquiry process and their learning	Child decides independently how to structure reflection on	Child is given broad guidelines to structure reflection on the inquiry process	Child is given a structured framework for reflection by the teacher,	

	the inquiry process and his/her learning	and his/her learning by the teacher, materials or other source	materials or other source	
h. If you have selected N/A, Please explain:				

21. How strongly do you agree or disagree with each of the following statements about the role of teacher in fostering INQUIRY skills?

	1 (Strongly disagree)	2 (Disagree)	3 (Agree)	4 (Strongly agree)
a. Teachers should demonstrate first the correct way to solve a problem				
b. Teachers should give children ample time to work out their own solutions to problems before showing them how they are solved				
c. Teachers should facilitate children's own inquiry				
d. Teachers should allow children to find solutions to problems on their own				

c) Your views about and approaches in assessing Science and Mathematics learning

22. Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of children's ASSESSMENT in SCIENCE education. To assess the development of children's:

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of scientific ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of scientific processes				
c. Competencies necessary to carry out scientific inquiry				
d. Understandings about scientific inquiry (e.g. how science and scientists work)				

e. Positive attitudes and increase of interest in science				
f. Positive attitudes and increase of interest in learning science				

23. Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of children's ASSESSMENT in MATHEMATICS education. To assess the development of children's:

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of mathematics ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of mathematic processes				
c. Competencies necessary to carry out mathematic inquiry				
d. Understandings about mathematic inquiry (e.g. how mathematics and mathematicians work)				
e. Positive attitudes and increase of interest in mathematics				
f. Positive attitudes and increase of interest in learning mathematics				

24. How often do you assess your pupils in SCIENCE in the following ways?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Using checklists to record observations of children				
b. During classroom interaction				
c. Evaluating children's pictures, graphs etc. which show their scientific reasoning				
d. Evaluating children's relevant gestures or physical activity				
e. Marking their homework				
f. Using authentic problem-based tasks				
g. Asking each child to reflect on their own learning and progress				
h. Using closed question tests				
i. Using open question tests				
j. Using questions in context				
k. Using portfolios (collection of evidence of children's work and progress)				

l. Children correcting each other's work and giving each other feedback				

25. How often do you assess your pupils in MATHEMATICS in the following ways?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Using checklists to record observations of children				
b. During classroom interaction				
c. Evaluating children's pictures, graphs etc. which show their scientific reasoning				
d. Evaluating children's relevant gestures or physical activity				
e. Marking their homework				
f. Using authentic problem-based tasks				
g. Asking each child to reflect on their own learning and progress				
h. Using closed question tests				
i. Using open question tests				
j. Using questions in context				
k. Using portfolios (collection of evidence of children's work and progress)				
l. Children correcting each other's work and giving each other feedback				

26. How often do you reward/praise the following characteristics in your pupils in SCIENCE?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Sense of initiative				
b. Motivation				
c. Ability to come up with something new				
d. Ability to connect what they have learnt during your lessons with topics in other subjects				
e. Imagination				
f. Curiosity				
g. Ability to work together				
h. Thinking skills				

27. How often do you reward/praise the following characteristics in your pupils in MATHEMATICS?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Sense of initiative				
b. Motivation				
c. Ability to come up with something new				
d. Ability to connect what they have learnt during your lessons with topics in other subjects				
e. Imagination				
f. Curiosity				
g. Ability to work together				
h. Thinking skills				

28. How often do you use ASSESSMENTS of children in SCIENCE for the following purposes?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To identify areas for improvement in your science teaching				
b. To identify aspects of the science curriculum that could be improved				
c. To identify ways to improve child science learning				
d. To monitor regularly individual children's or group of children's progress towards a set of desirable science learning outcomes				
e. To inform parents of their child's progress in science				
f. To help group children for science instruction purposes				
g. To monitor year-to-year child progress in science				
h. To provide feedback to children about their progress in science				
i. To set targets with children for their own development in science				

29. How often do you use ASSESSMENTS of children in MATHEMATICS for the following purposes?

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)

a. To identify areas for improvement in your mathematics teaching				
b. To identify aspects of the mathematics curriculum that could be improved				
c. To identify ways to improve child mathematics learning				
d. To monitor regularly individual children's or group of children's progress towards a set of desirable mathematics learning outcomes				
e. To inform parents of their child's progress in mathematics				
f. To help group children for mathematics instruction purposes				
g. To monitor year-to-year child progress in mathematics				
h. To provide feedback to children about their progress in mathematics				
i. To set targets with children for their own development in mathematics				

d) School Science and Mathematics Resources and Your Use of Them

30. How well resourced do you feel your school is for the teaching of SCIENCE in terms of the following?

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional materials(e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				

31. How well resourced do you feel your school is for the teaching of MATHEMATICS in terms of the following?

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional materials(e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				

32. How often do you use the following resources in your SCIENCE teaching?

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. Resources downloaded from the Internet					
e. Audio-visual resources					
f. Relevant library materials (e.g. story books)					
g. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					
h. Computers					
i. Digital technologies (e.g. interactive whiteboard)					

j. ICT resources (e.g. website, digital game)					
k. Relevant media materials (e.g. newspapers, magazines)					
l. Other resources that you often use in your Science teaching:					

33. How often do you use the following resources in your MATHEMATICS teaching?

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. Resources downloaded from the Internet					
e. Audio-visual resources					
f. Relevant library materials (e.g. story books)					
g. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					
h. Computers					
i. Digital technologies (e.g. interactive whiteboard)					
j. ICT resources (e.g. website, digital game)					
k. Relevant media materials (e.g. newspapers, magazines)					
l. Other resources that you often use in your Mathematics teaching:					

34. How often do you consult the following resources to inform your SCIENCE teaching preparation?

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A

a. Student Textbooks					
b. Teacher textbook guide					
c. Online textbook resources (incl. publishers' websites)					
d. School curriculum					
e. National curriculum					
f. National teacher curriculum guide					
g. National education agency website					
h. Teacher professional association documentation or website					
i. School assessment guidelines					
j. National assessment guidelines					
k. Other resources that you often use to inform your Science teaching:					

35. How often do you consult the following resources to inform your MATHEMATICS teaching preparation?

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teacher textbook guide					
c. Online textbook resources (incl. publishers' websites)					
d. School curriculum					
e. National curriculum					
f. National teacher curriculum guide					
g. National education agency website					
h. Teacher professional association documentation or website					
i. School assessment guidelines					
j. National assessment guidelines					
k. Other resources that you often use to inform your Mathematics teaching:					

ADDENDUM C – DATA FROM ADAPTED QUESTIONNAIRE

Question 1-9: These questions was used to receive demographical data (some of which is personal data) about participants as represented in chapter 4 and will not be stated here.

Pedagogical phenomenon: Content and curriculum

The following questions provide data supporting this pedagogical phenomenon in South Africa: question 10 (the time that the teachers makes available per week for teaching Mathematics and Science), 11 themes that the teachers has covered throughout the years), 12 (the teachers views on the importance of school Sciences in compulsory education), 13 (the teachers implementation of fostering the development of Science learning outcomes) and 14 (the teachers implementation of fostering the development of Mathematics learning outcomes).

Question 10

“Approximately how much time do you have planned for teaching Science and Mathematics per week?”

	Science	Mathematics
a. Less than an hour		
b. 1-2 hours		
c. 3-4 hours		
d. More than 4 hours		
e. N/A (please explain)		

Table: Question 10 -Time spent on teaching

The data from question 10 is reported in figure 4.4 (Science) and 4.5 (Mathematics) separately.

4.4.2 Question 11

“List up to five **SCIENCE** and **MATHEMATICS** topics you have addressed in your teaching this school year:”

	Science	Mathematics
a.		
b.		

c.		
d.		
e.		

Table: Question 11 - Topics addressed in Science and Mathematics

The data from question 11 is reported in figure 4.6 (Science) and 4.7 (Mathematics) separately.

Question 12

“Please indicate your view on the importance of the following purpose of school SCIENCES (Science and Mathematics) in compulsory education (Grade R-12).”

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. To provide a foundational education for future scientists and engineers				
b. To develop socially and environmentally aware and responsible citizens				
c. To enrich the understanding and interaction with phenomena in nature and technology				
d. To develop more innovative thinkers				
e. To develop positive attitudes to sciences				
f. To develop important attitudes and dispositions as a foundation for future learning				

Table: Question 12 - Purpose of Sciences in compulsory education

The data reflecting the findings from question 12 a to f was fused into one graph as seen in figure 4.8.

Question 13

“Please indicate how often you foster the development of the following SCIENCE learning outcomes”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To know and understand the important scientific ideas (facts, concepts, laws and theories)				

b. To understand that scientists describe the investigations in ways that enable others to repeat the investigations.				
c. To be able to ask a question about objects, organisms, and events in the environment.				
d. To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.				
e. To know and understand important scientific processes.				
f. To be able to communicate investigations and explanations				
g. To understand that scientific investigations involve asking and answering a question and comparing the answer with what scientists already know about the world.				
h. To have positive attitudes to science learning.				
i. To be interested in science.				
j. To be able to plan and conduct a simple investigation.				
k. To have positive attitudes to learning.				
l. To understand that scientists develop explanations using observations (evidence) and what they already know about the world (scientific knowledge).				
m. To be able to collaborate with other children				

Table: Question 13 - Fostering the development of SCIENCE learning outcomes

The data reflecting the findings from question 13 sub-question a remained as sub-question a on table 4-8 and is reflected in figure 4.9.

The data reflecting the findings from question 13 sub-questions b, c, d, e, g, j and l was fused into sub-question b on table 4-8 and is reflected in figure 4.10.

The data reflecting the findings from question 13 sub-question c remained as sub-question c on table 4-8 and is reflected in figure 4.11.

The data reflecting the findings from question 13 sub-questions h, i, k and m was fused into sub-question d on table 4-8 and is reflected in figure 4.12.

Question 14

“Please indicate how often you foster the development of the following MATHEMATICS learning outcomes”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To know and understand the important mathematics ideas (facts, concepts, laws and theories)				
b. To understand that mathematicians describe the mathematics problems in ways that enable others to repeat the process.				
c. To be able to ask a question about objects and events in mathematics content.				
d. To be able to employ simple equipment and tools, such as magnifiers, thermometers, and rulers, to gather data and extend to the senses.				
e. To know and understand important mathematic processes.				
f. To be able to communicate investigations and explanations				
g. To understand that mathematic problem solving involve asking and answering a question and comparing the answer with what mathematicians already know about the world.				
h. To have positive attitudes to mathematics learning.				
i. To be interested in mathematics.				
j. To be able to plan and conduct a simple investigation.				
k. To have positive attitudes to learning.				
l. To understand that mathematicians develop explanations using observations (evidence) and what they already know about the world (mathematic knowledge).				
m. To be able to collaborate with other children				

Table: Question 14 - Fostering the development of Mathematics learning outcomes

The data reflecting the findings from question 14 sub-question a remained as sub-question a on table 4-9 and is reflected in figure 4.13.

The data reflecting the findings from question 14 sub-questions b, c, d, e, g, j and l was fused into sub-question b on table 4-9 and is reflected in figure 4.14.

The data reflecting the findings from question 14 sub-question c remained as sub-question c on table 4-9 and is reflected in figure 4.15.

The data reflecting the findings from question 14 sub-questions h, i, k and m was fused into sub-question d on table 4-9 and is reflected in figure 4.16.

Pedagogical phenomenon: Assessment

The following questions provide data supporting this pedagogical phenomenon in South Africa: The following questions provide data supporting this pedagogical phenomenon in South Africa: question 22 (the teachers views on the importance of assessment of Science in the age group that they teach), 23 (the teachers views on the importance of assessment of Science in the age group that they teach), 24 (how often does the teacher asses the learners in Science using check lists, classroom interaction, homework etc.), 25 (how often does the teacher asses the learners in Mathematics using check lists, classroom interaction, homework etc.), 26 (how often does the teacher reward of praise, informal assessment, characteristics of pupils in Science class), 27 (how often does the teacher reward of praise, informal assessment, characteristics of pupils in Mathematics class), 28 (how often does the teacher asses the learners to determine progression, development and improvement in Science) and 29 (how often does the teacher asses the learners to determine progression, development and improvement in Mathematics).

Question 22

“Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of children’s ASSESSMENT in SCIENCE education. To assess the development of children’s:”

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of scientific ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of scientific processes				
c. Competencies necessary to carry out scientific inquiry				
d. Understandings about scientific inquiry (e.g. how science and scientists work)				
e. Positive attitudes and increase of interest in science				
f. Positive attitudes and increase of interest in learning science				

Table: Question 22 - Age group priorities in Science education

The data reflecting the findings from question 22 sub-question a remained as sub-question a on table 4-10 and is reflected in figure 4.17.

The data reflecting the findings from question 22 sub-questions b, c and d was fused into sub-question b on table 4-10 and is reflected in figure 4.18.

The data reflecting the findings from question 22 sub-questions e and f was fused into sub-question c on table 4-10 and is reflected in figure 4.19.

Question 23

“Focusing on the AGE GROUP YOU TEACH, please indicate your views about the importance of the following priorities of children’s ASSESSMENT in MATHEMATICS education. To assess the development of children’s:”

	1 (Not important)	2 (Less important)	3 (Important)	4 (Very important)
a. Knowledge and understanding of mathematics ideas (facts, concepts, laws and theories)				
b. Knowledge and understanding of mathematic processes				
c. Competencies necessary to carry out mathematic inquiry				
d. Understandings about mathematic inquiry (e.g. how mathematics and mathematicians work)				
e. Positive attitudes and increase of interest in mathematics				
f. Positive attitudes and increase of interest in learning mathematics				

Table: Question 23- Age group priorities in Mathematics education

The data reflecting the findings from question 23 sub-question a remained as sub-question a on table 4-11 and is reflected in figure 4.20.

The data reflecting the findings from question 23 sub-questions b, c and d was fused into sub-question b on table 4-11 and is reflected in figure 4.21.

The data reflecting the findings from question 23 sub-questions e and f was fused into sub-question c on table 4-11 and is reflected in figure 4.22.

Question 24

“How often do you assess your pupils in SCIENCE in the following ways?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Using checklists to record observations of children				
b. During classroom interaction				
c. Evaluating children's pictures, graphs etc. which show their scientific reasoning				
d. Evaluating children's relevant gestures or physical activity				
e. Marking their homework				
f. Using authentic problem-based tasks				
g. Asking each child to reflect on their own learning and progress				
h. Using closed question tests				
i. Using open question tests				
j. Using questions in context				
k. Using portfolios (collection of evidence of children's work and progress)				
l. Children correcting each other's work and giving each other feedback				

Table: Question 24 - Frequency of assessment in Science

The data reflecting the findings from question 24 sub-questions c, e, f and k was fused into sub-question a on table 4-12 and is reflected in figure 4.23.

The data reflecting the findings from question 24 sub-question d remained separate as sub-question b on table 4-12 and is reflected in figure 4.24.

The data reflecting the findings from question 24 sub-questions g, j and l was fused into sub-question c on table 4-12 and is reflected in figure 4.25.

The data reflecting the findings from question 24 sub-questions h and i was fused into sub-question c on table 4-12 and is reflected in figure 4.26.

Question 25

“How often do you assess your pupils in MATHEMATICS in the following ways?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Using checklists to record observations of children				

b. During classroom interaction				
c. Evaluating children's pictures, graphs etc. which show their scientific reasoning				
d. Evaluating children's relevant gestures or physical activity				
e. Marking their homework				
f. Using authentic problem-based tasks				
g. Asking each child to reflect on their own learning and progress				
h. Using closed question tests				
i. Using open question tests				
j. Using questions in context				
k. Using portfolios (collection of evidence of children's work and progress)				
l. Children correcting each other's work and giving each other feedback				

Table: Question 25 - Frequency of assessment in Mathematics

The data reflecting the findings from question 25 sub-questions c, e, f and k was fused into sub-question a on table 4-19 and is reflected in figure 4.27.

The data reflecting the findings from question 25 sub-question d remained separate as sub-question b on table 4-19 and is reflected in figure 4.28.

The data reflecting the findings from question 25 sub-questions g, j and l was fused into sub-question c on table 4-19 and is reflected in figure 4.29.

The data reflecting the findings from question 25 sub-questions h and i was fused into sub-question c on table 4-19 and is reflected in figure 4.30.

Question 26

“How often do you reward/praise the following characteristics in your pupils in SCIENCE?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Sense of initiative				
b. Motivation				
c. Ability to come up with something new				
d. Ability to connect what they have learnt during your lessons with topics in other subjects				

e. Imagination				
f. Curiosity				
g. Ability to work together				
h. Thinking skills				

Table: Question 26 - Frequency of reward/praise in Science

The data reflecting the findings from question 26 sub-questions a to h fused into one graph and is reflected in figure 4.31.

Question 27

“How often do you reward/praise the following characteristics in your pupils in MATHEMATICS?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Sense of initiative				
b. Motivation				
c. Ability to come up with something new				
d. Ability to connect what they have learnt during your lessons with topics in other subjects				
e. Imagination				
f. Curiosity				
g. Ability to work together				
h. Thinking skills				

Table: Question 27 - Frequency of reward/praise in Mathematics

The data reflecting the findings from question 27 sub-questions a to h fused into one graph and is reflected in figure 4.32.

Question 28

“How often do you use ASSESSMENTS of children in SCIENCE for the following purposes?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)

a. To identify areas for improvement in your science teaching				
b. To identify aspects of the science curriculum that could be improved				
c. To identify ways to improve child science learning				
d. To monitor regularly individual children's or group of children's progress towards a set of desirable science learning outcomes				
e. To inform parents of their child's progress in science				
f. To help group children for science instruction purposes				
g. To monitor year-to-year child progress in science				
h. To provide feedback to children about their progress in science				
i. To set targets with children for their own development in science				

Table: Question 28 - Frequency of assessment in Science

The data reflecting the findings from question 28 sub-questions a to i fused into one graph and is reflected in figure 4.33.

4.5.6 Question 29

“How often do you use ASSESSMENTS of children in MATHEMATICS for the following purposes?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. To identify areas for improvement in your mathematics teaching				
b. To identify aspects of the mathematics curriculum that could be improved				
c. To identify ways to improve child mathematics learning				
d. To monitor regularly individual children's or group of children's progress towards a set of desirable mathematics learning outcomes				
e. To inform parents of their child's progress in mathematics				
f. To help group children for mathematics instruction purposes				
g. To monitor year-to-year child progress in mathematics				
h. To provide feedback to children about their progress in mathematics				
i. To set targets with children for their own development in mathematics				

Table: Question 29 - Frequency of assessment in Mathematics

The data reflecting the findings from question 29 sub-questions a to i fused into one graph and is reflected in figure 4.34.

4.6 Method

The following questions provide data supporting this pedagogical phenomenon in South Africa: question 15 (how often does the teacher use specific learning and teaching contexts and approaches when teaching Science), 16 (how often does the teacher use specific learning and teaching contexts and approaches when teaching Mathematics), 17 (how often does the teacher encourage activities such as observing, design and construction in Science), 18 (how often does the teacher encourage activities such as observing, design and construction in Mathematics), 19 (what approach open, guided or structures does the teacher follow in the Science classroom) 20 (what approach open, guided or structures does the teacher follow in the Mathematics classroom) 21 (what is the teachers view on the role of the teacher in fostering inquiry skills).

Question 15

“How often do you use the following learning/teaching contexts and approaches in your SCIENCE teaching?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Open/unstructured play				
b. Role/Pretend play				
c. Drama				
d. Teaching science from stories				
e. Using history to teach science (e.g. transport, the work of scientists)				
f. Working in small groups				
g. Physical exploration of materials				
h. Using outdoor learning activities				
i. Taking children on field trips and/or visits to science museums and industry				
j. Integrating science with other curricular areas				
k. Building on children’s prior experiences				
l. Encouraging different ways of recording and expressing ideas –oral, visual, digital, practical				

m. Encouraging problem finding –e.g. children asking questions				
n. Encouraging problem solving –e.g. children solving practical tasks				
o. Encouraging children to try out their own ideas in investigations				
p. Fostering classroom discussion and evaluation of alternative ideas				
q. Fostering imagination				
r. Relating science to everyday life				
s. Using questioning as a tool in science teaching				
t. Using digital technologies with children for science teaching and learning				
u. Fostering autonomous learning				

Table: Question 15 - Context and approaches in Science

The data reflecting the findings from question 15 sub-questions a, b, c, f, g, h, l, m, n, o, p, q, s, t and u was fused into sub-question a on table 4-29 and is reflected in figure 4.35.

The data reflecting the findings from question 15 sub-questions d, e, i, j, and r was fused into sub-question c on table 4-29 and is reflected in figure 4.38.

Question 16

“How often do you use the following learning/teaching contexts and approaches in your MATHEMATICS teaching?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Open/unstructured play				
b. Role/Pretend play				
c. Drama				
d. Teaching mathematics from stories				
e. Using history to teach mathematics (e.g. using Pythagoras and solving everyday construction problems)				
f. Working in small groups				
g. Physical exploration of materials				
h. Using outdoor learning activities				

i. Taking children on trips and/or visits to computer labs to work with mathematics software				
j. Integrating mathematics with other curricular areas				
k. Building on children's prior experiences				
l. Encouraging different ways of recording and expressing ideas –oral, visual, digital, practical				
m. Encouraging problem finding –e.g. children asking questions				
n. Encouraging problem solving –e.g. children solving practical tasks				
o. Encouraging children to try out their own ideas in investigations				
p. Fostering classroom discussion and evaluation of alternative ideas				
q. Fostering imagination				
r. Relating mathematics to everyday life				
s. Using questioning as a tool in mathematics teaching				
t. Using digital technologies with children for mathematics teaching and learning				
u. Fostering autonomous learning				

Table: Question 16 - Context and approaches in Mathematics

The data reflecting the findings from question 16 sub-questions a, b, c, f, g, h, l, m, n, o, p, q, s, t and u was fused into sub-question a on table 4-30 and is reflected in figure 4.39.

The data reflecting the findings from question 16 sub-questions d, e, i, j, and r was fused into sub-question c on table 4-30 and is reflected in figure 4.41.

Question 17

“How often do you encourage children to undertake the following activities in SCIENCE?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe natural phenomena such as the weather or a plant growing and describe what they see.				
b. Ask questions about objects, organisms, and events in the environment				
c. Design or plan simple investigations or projects				
d. Conduct simple investigations or projects				

e. Employ simple equipment and tools to gather data and extend to the senses.				
f. Use data to construct reasonable explanations.				
g. Communicate the results of their investigations and explanations.				

Table: Question 17 - Activities in Science

The data reflecting the findings from question 17 sub-questions a remained as sub-question a on table 4.31 and is reflected in figure 4.42.

The data reflecting the findings from question 17 sub-questions b remained as sub-question b on table 4.31 and is reflected in figure 4.44.

The data reflecting the findings from question 17 sub-questions c, d and e was fused into sub-question c on table 4-31 and is reflected in figure 4.46.

The data reflecting the findings from question 17 sub-questions f was reported separately as sub-question d on table 4.31 and is reflected in figure 4.48.

The data reflecting the findings from question 17 sub-questions g was reported separately as sub-question e on table 4.31 and is reflected in figure 4.49.

Question 18

“How often do you encourage children to undertake the following activities in MATHEMATICS?”

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)
a. Observe phenomena using tables and formulas.				
b. Ask questions about objects and events about mathematic content in real life situations.				
c. Design or plan simple investigations or projects				
d. Conduct simple investigations or projects				
e. Employ simple equipment and tools to gather data and extend to the senses.				
f. Use data to construct reasonable explanations.				
g. Communicate the results of their investigations and explanations.				

Table: Question 18 - Activities in Mathematics

The data reflecting the findings from question 18 sub-questions a remained as sub-question a on table 4.32 and is reflected in figure 4.50.

The data reflecting the findings from question 18 sub-questions b remained as sub-question b on table 4.32 and is reflected in figure 4.51.

The data reflecting the findings from question 18 sub-questions c, d and e was fused into sub-question c on table 4-32 and is reflected in figure 4.53.

The data reflecting the findings from question 18 sub-questions f was reported separately as sub-question d on table 4.32 and is reflected in figure 4.55.

The data reflecting the findings from question 18 sub-questions g was reported separately as sub-question e on table 4.32 and is reflected in figure 4.57.

Question 19

“For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the SCIENCE classroom. (Please indicate your choice on the block with the description)”

	A (Open)	B (Guided)	C (Structured)	N/A
a. QUESTION: Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher, materials or other source	Child is given a scientifically oriented question by the teacher, materials or other source	
b. EVIDENCE: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source	
c. ANALYSE: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher,	Child is told how to analyse evidence provided by the teacher, materials or other source	

		materials or other source		
d. EXPLAIN: Children formulate explanations based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence	
e. CONNECT: Children connect explanations to scientific knowledge	Child independently finds and examines other resources and forms links to scientific knowledge	Child is directed to other resources and shown how to form links to scientific knowledge	Child is given other resources and shown the links with scientific knowledge	
f. COMMUNICATE: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source	
g. REFLECT: Children reflect on the inquiry process and their learning	Child decides independently how to structure reflection on the inquiry process and his/her learning	Child is given broad guidelines to structure reflection on the inquiry process and his/her learning by the teacher, materials or other source	Child is given a structured framework for reflection by the teacher, materials or other source	
h. If you have selected N/A, Please explain:				

Table: Question 19 - Inquiry features in Science classroom

The data reflecting the findings from question 19 sub-questions a to g was fused into sub-question a on table 4-33 and is reflected in figure 4.59.

Question 20

“For each of the inquiry features please indicate the variation (A, B or C) from the table that mostly characterizes your approach in the MATHEMATICS classroom. (Please indicate your choice on the block with the description)”

	A (Open)	B (Guided)	C (Structured)	N/A
a. QUESTION: Children investigate scientifically oriented question	Child poses a scientifically oriented question	Child selects from a range of, or refines, a scientifically oriented question provided by the teacher, materials or other source	Child is given a scientifically oriented question by the teacher, materials or other source	
b. EVIDENCE: Children give priority to evidence	Child determines what constitutes evidence/data and collects it	Child selects from data/evidence provided by the teacher, materials or other source	Child is given evidence/data by the teacher, materials or other source	
c. ANALYSE: Children analyse evidence	Child decides how to analyse evidence	Child selects from ways of analysing evidence provided by the teacher, materials or other source	Child is told how to analyse evidence provided by the teacher, materials or other source	
d. EXPLAIN: Children formulate explanations based on evidence	Child decides how to formulate evidence based on evidence	Child selects from possible ways to formulate explanation given by the teacher, materials or other source	Child is given a way to formulate explanation based on evidence	
e. CONNECT: Children connect explanations to scientific knowledge	Child independently finds and examines other resources and forms links to scientific knowledge	Child is directed to other resources and shown how to form links to scientific knowledge	Child is given other resources and shown the links with scientific knowledge	
f. COMMUNICATE: Children communicate and justify explanation	Child chooses how to communicate and justify explanations	Child is given broad guidelines on how to justify and communicate explanations	Child is given all the steps to justify and communicate explanations by the teacher, materials or other source	
g. REFLECT: Children reflect	Child decides independently	Child is given broad guidelines	Child is given a structured	

on the inquiry process and their learning	how to structure reflection on the inquiry process and his/her learning	to structure reflection on the inquiry process and his/her learning by the teacher, materials or other source	framework for reflection by the teacher, materials or other source	
h. If you have selected N/A, Please explain:				

Table: Question 20 - Inquiry features in Mathematics classroom

The data reflecting the findings from question 20 sub-questions a to g was fused into sub-question a on table 4-34 and is reflected in figure 4.60.

Question 21

“How strongly do you agree or disagree with each of the following statements about the role of teacher in fostering INQUIRY skills?”

	1 (Strongly disagree)	2 (Disagree)	3 (Agree)	4 (Strongly agree)
a. Teachers should demonstrate first the correct way to solve a problem				
b. Teachers should give children ample time to work out their own solutions to problems before showing them how they are solved				
c. Teachers should facilitate children's own inquiry				
d. Teachers should allow children to find solutions to problems on their own				

Table: Question 21 - Role of teacher in fostering inquiry

The data reflecting the findings from question 21 sub-questions a remained as sub-question a on table 4-35 and is reflected in figure 4.61.

The data reflecting the findings from question 21 sub-questions b, c and d was fused into sub-question b on table 4-35 and is reflected in figure 4.62.

4.7 Resources

The following questions provide data supporting this pedagogical phenomenon in South Africa: question 30 (availability of resources for Science at the school), 31 (availability of resources for Mathematics at the school), 32 (how often the available resources is used in the teaching of Mathematics), 33 (how often the available resources is used in the teaching of Science), 34 (how does a teacher consult available resources in preparation for a Science lessons) and 35 (how does a teacher consult available resources in preparation for a Mathematics lessons) are all related to resources available and used within teaching of the Sciences.

Question 30

“How well resourced do you feel your school is for the teaching of SCIENCE in terms of the following?”

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional materials(e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				

Table: Question 30 – Resources available in school for teaching Science

The data reflecting the findings from question 30 sub-questions a and c was fused into sub-question a on table 4-36 and is reflected in figure 4.63.

The data reflecting the findings from question 30 sub-questions b, f, g and h was fused into sub-question b on table 4-36 and is reflected in figure 4.65.

The data reflecting the findings from question 30 sub-questions d and e was fused into sub-question c on table 4-36 and is reflected in figure 4.66.

The data reflecting the findings from question 30 sub-questions i was reported separately as sub-question d on table 4-36 and is reflected in figure 4.68.

The data reflecting the findings from question 30 sub-questions j and k was fused into sub-question c on table 4-36 and is reflected in figure 4.70.

Question 31

“How well resourced do you feel your school is for the teaching of MATHEMATICS in terms of the following?”

	1 (Not at all)	2 (Basic)	3 (Well)	4 (Very well)
a. Instructional materials(e.g. textbooks)				
b. Audio-visual resources				
c. Relevant library materials (e.g. story books)				
d. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks)				
e. Equipment and materials for hands-on exploration outside the classroom (e.g. sand box)				
f. Computers				
g. ICT resources (e.g. computer applications)				
h. Other digital technologies (e.g. interactive whiteboard, camera)				
i. Budget for supplies (e.g. paper, drawing materials)				
j. Teaching support personnel (e.g. classroom assistant)				
k. Other support personnel (e.g. technical support)				

Table: Question 31 – Resources available in school for teaching Mathematics

The data reflecting the findings from question 31 sub-questions a and c was fused into sub-question a on table 4-39 and is reflected in figure 4.71.

The data reflecting the findings from question 31 sub-questions b, f, g and h was fused into sub-question b on table 4-39 and is reflected in figure 4.72.

The data reflecting the findings from question 31 sub-questions d and e was fused into sub-question c on table 4-39 and is reflected in figure 4.74.

The data reflecting the findings from question 31 sub-questions i was reported separately as sub-question d on table 4-39 and is reflected in figure 4.75.

The data reflecting the findings from question 31 sub-questions j and k was fused into sub-question c on table 4-39 and is reflected in figure 4.76.

Question 32

“How often do you use the following resources in your SCIENCE teaching?”

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. Resources downloaded from the Internet					
e. Audio-visual resources					
f. Relevant library materials (e.g. story books)					
g. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					
h. Computers					
i. Digital technologies (e.g. interactive whiteboard)					
j. ICT resources (e.g. website, digital game)					
k. Relevant media materials (e.g. newspapers, magazines)					
l. Other resources that you often use in your Science teaching:					

Table: Question 32 – Use of resources in Science teaching activities

The data reflecting the findings from question 32 sub-questions a, f and k was fused into sub-question a on table 4-40 and is reflected in figure 4.77.

The data reflecting the findings from question 32 sub-questions b remained as sub-question b on table 4-40 and is reflected in figure 4.78.

The data reflecting the findings from question 32 sub-questions c remained as sub-question c on table 4-40 and is reflected in figure 4.79.

The data reflecting the findings from question 32 sub-questions d, e, h, i and j was fused into sub-question d on table 4-40 and is reflected in figure 4.80.

The data reflecting the findings from question 32 sub-questions g was reported separately as sub-question e on table 4-40 and is reflected in figure 4.81.

Question 33

“How often do you use the following resources in your MATHEMATICS teaching?”

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teaching materials prepared by you					
c. Teaching materials prepared by group of teachers in your school					
d. Resources downloaded from the Internet					
e. Audio-visual resources					
f. Relevant library materials (e.g. story books)					
g. Equipment and materials for hands-on exploration in the classroom (e.g. magnets, building blocks, sorting activity games, rulers)					
h. Computers					
i. Digital technologies (e.g. interactive whiteboard)					

j. ICT resources (e.g. website, digital game)					
k. Relevant media materials (e.g. newspapers, magazines)					
l. Other resources that you often use in your Mathematics teaching:					

Table: Question 33 – Use of resources in Mathematics teaching activities

The data reflecting the findings from question 33 sub-questions a, f and k was fused into sub-question a on table 4-41 and is reflected in figure 4.84.

The data reflecting the findings from question 33 sub-questions b remained as sub-question b on table 4-41 and is reflected in figure 4.85.

The data reflecting the findings from question 33 sub-questions c remained as sub-question c on table 4-41 and is reflected in figure 4.87.

The data reflecting the findings from question 33 sub-questions d, e, h, i and j was fused into sub-question d on table 4-41 and is reflected in figure 4.88.

The data reflecting the findings from question 33 sub-questions g was reported separately as sub-question e on table 4-41 and is reflected in figure 4.89.

Question 34

“How often do you consult the following resources to inform your SCIENCE teaching preparation?”

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teacher textbook guide					
c. Online textbook resources (incl. publishers' websites)					
d. School curriculum					
e. National curriculum					

f. National teacher curriculum guide					
g. National education agency website					
h. Teacher professional association documentation or website					
i. School assessment guidelines					
j. National assessment guidelines					
k. Other resources that you often use to inform your Science teaching:					

Table: Question 34 – Use of resources to inform Science teaching activities

The data reflecting the findings from question 34 sub-questions a, b and c was fused into sub-question a on table 4-42 and is reflected in figure 4.91.

The data reflecting the findings from question 34 sub-questions d, e, f, i and j was fused into sub-question b on table 4-42 and is reflected in figure 4.92.

The data reflecting the findings from question 34 sub-questions g and h was fused into sub-question c on table 4-42 and is reflected in figure 4.93.

Question 35

“How often do you consult the following resources to inform your MATHEMATICS teaching preparation?”

*Never – have the resource in class or school but never use

N/A – not applicable because you do not have the resource in class or school

	1 (Never)	2 (Rarely)	3 (Quite often)	4 (Very often)	N/A
a. Student Textbooks					
b. Teacher textbook guide					
c. Online textbook resources (incl. publishers' websites)					
d. School curriculum					
e. National curriculum					
f. National teacher curriculum guide					
g. National education agency website					

h. Teacher professional association documentation or website					
i. School assessment guidelines					
j. National assessment guidelines					
k. Other resources that you often use to inform your Mathematics teaching:					

Table: Question 35 – Use of resources to inform Mathematics teaching activities

The data reflecting the findings from question 35 sub-questions a, b and c was fused into sub-question a on table 4-45 and is reflected in figure 4.94.

The data reflecting the findings from question 35 sub-questions d, e, f, i and j was fused into sub-question b on table 4-45 and is reflected in figure 4.95.

The data reflecting the findings from question 35 sub-questions g and h was fused into sub-question c on table 4-45 and is reflected in figure 4.96.

ADDENDUM D – ETHICAL CLEARANCE CERTIFICATE



Private Bag X1290, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Fax: 018 299-4910
Web: <http://www.nwu.ac.za>

Senate Committee for Research Ethics
Tel: 018 299-4849
Email: nkosinathi.machine@nwu.ac.za

ETHICS APPROVAL LETTER OF STUDY

Based on approval by the **Faculty of Education Research Ethics Committee (EduREC)** on 29 July 2021, this committee hereby **approves** your study as indicated below. This implies that the North-West University Senate Committee for Research Ethics (NWU-SCRE) grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the study may be initiated, using the ethics number below.

Study title: Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3

Study Leader/Supervisor (Principal Investigator)/Researcher: Dr HM van Niekerk

Student / Team: SE Prinsloo (PhD student – 20356404)

Ethics number:

N	W	U	-	0	1	9	2	0	-	2	0	-	A	2

Institution

Study Number

Year

Status

Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation

Application Type: Single study

Commencement date: 29 July 2021

Risk:

Low

Expiry date: 29 July 2022

Approval of the study is initially provided for a year, after which continuation of the study is dependent on receipt and review of the annual (or as otherwise stipulated) monitoring report and the concomitant issuing of a letter of continuation.

Special in process conditions of the research for approval (if applicable):

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, the following general terms and conditions will apply:

- The study leader/supervisor/principal investigator/researcher must report in the prescribed format to the EduREC:
 - annually (or as otherwise requested) on the monitoring of the study, whereby a letter of continuation will be provided, and upon completion of the study; and
 - without any delay in case of any adverse event or incident (or any matter that interrupts sound ethical principles) during the course of the study.
- The approval applies strictly to the proposal as stipulated in the application form. Should any amendments to the proposal be deemed necessary during the course of the study, the study leader/researcher must apply for approval of these amendments at the EduREC, prior to implementation. Should there be any deviations from the study proposal without the necessary approval of such amendments, the ethics approval is immediately and automatically forfeited.
- Annually a number of studies may be randomly selected for an external audit.
- The date of approval indicates the first date that the study may be started.
- In the interest of ethical responsibility, the NWU-SCRC and EduREC reserves the right to:
 - request access to any information or data at any time during the course or after completion of the study;

- *to ask further questions, seek additional information, require further modification or monitor the conduct of your research or the informed consent process;*
- *withdraw or postpone approval if:*
 - *any unethical principles or practices of the study are revealed or suspected;*
 - *it becomes apparent that any relevant information was withheld from the EduREC or that information has been false or misrepresented;*
 - *submission of the annual (or otherwise stipulated) monitoring report, the required amendments, or reporting of adverse events or incidents was not done in a timely manner and accurately; and / or*
 - *new institutional rules, national legislation or international conventions deem it necessary.*

The EduREC would like to remain at your service as scientist and researcher, and wishes you well with your study. Please do not hesitate to contact the EduREC or the NWU-SCRE for any further enquiries or requests for assistance.

Yours sincerely



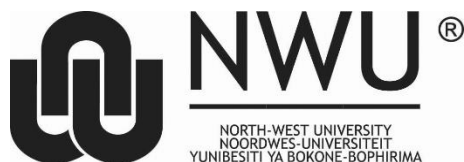
Prof JAK Olivier
Chairperson NWU Faculty of Education Research Ethics Committee

Original details: (22351930) C:\Users\22351930\Desktop\ETHICS APPROVAL LETTER OF STUDY.docm
8 November 2018

Current details: (22351930) M:\DSS1\9533\Monitoring and Reporting Cluster\Ethics\Certificates\Templates\Research Ethics Approval Letters\9.1.5.4.1 ES-REC Ethical Approval Letter.docm
5 December 2018

File reference: 9.1.5.4.2

ADDENDUM E – AUTHORISATION LETTER – PROVINCIAL DEPARTMENT OF EDUCATION OR PRINCIPALS



Private Bag X6001, Potchefstroom
South Africa 2520

Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Faculty of Education

(Research entity details: ROE)

Tel: 018 299 1870
Email: Liztie.prinsloo@nwu.ac.za

Date 18/06/2021

PERMISSION LETTER: PROVINCIAL DEPARTMENT OF EDUCATION/SCHOOL PRINCIPAL

I herewith wish to request your permission for in-service teachers of Grade R-3 to participate in this research, which involves a research study to determine the current state of STEM education with regards to teaching and learning the sciences in Grade R-3. This research aims to answer the current international call for the development of STEM education related research looking at the Grade R-3. This research will provide the African continent with a comprehensive example from South Africa regarding existing and possible practices dealing with STEM as a trans-disciplinary field of research for learners from grade R, 1, 2 and 3. With the knowledge gained from the research the aim will be to make a concrete contribution towards ultimately giving motivations for impacting curriculum policies. Further this study will include contributions towards in service and pre-service training for educators involved in teaching learners between the ages relevant to grade R, 1, 2, and 3. Prior to granting permission, please acquaint yourself with the information below.

The details of the research are as follows:

TITLE OF THE RESEARCH PROJECT:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

ETHICS APPLICATION NUMBER

NWU-01920-20-S2

PROJECT SUPERVISOR: Dr HM van Niekerk

CO-SUPERVISOR: Prof CC Wolhuter

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

MEMBER OF PROJECT TEAM PhD-Student: SE Prinsloo

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

FACULTY OF EDUCATION RESEARCH ETHICS COMMITTEE

Contact person: Ms Erna Greyling, E-mail: Erna.Greyling@nwu.ac.za, Tel. (018) 299 4656

This study has been approved by the Research Ethics Committee of the Faculty of Education of the North-West University and will be conducted according to the ethical guidelines of this committee. Permission was also obtained from the provincial Department of Basic Education/other relevant body.

What is this research about?

The aims of this research is:

- To conceptualize the teaching, learning, and assessment of the natural sciences for Grade R to 3.
- To describe the instruction methods used by teachers for the natural sciences in Grade R-3 with focus on inquiry-based learning, creativity and play.
- To identify the availability, utilization, conceptualization and implementation of resources used in the natural sciences in Grade R-3.
- To propose a framework for policy purposes in order to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development.

Participants

The target population for this study is in-service teachers currently teaching Gr R to 3 in South Africa. The complex nature of the general population in South Africa calls for the inclusion of specific schools where the learners are multi-cultural, ethnic minorities, from different socio-economic status and have different contextual factors present. For the purpose of this study we will then be focusing on teachers in service of Former Model C, farm and rural schools.

What is expected of the participants?

1. Questionnaire completed by the teachers.
2. Allow time for follow-up interview if clarification is needed on questionnaire.
3. Provide anonymised artefacts (mathematics and science lesson plan and classwork).
4. Allow researcher to map out the space (i.e. classroom).

Benefits to the participants

Direct benefits include insight into the current policy and implementation of STEM education in each teachers individual grade. Insight into each teachers own individual approach to STEM education.

Indirect benefits include contributing towards a better understanding of the current state of STEM education in South Africa. Furthermore, contributing a better understanding in order for the researcher to the development of a framework for policy to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development

Risks involved for participants

The study involves the normal educational practices, such as research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods and should therefore cause minimal risks to participants. Even with minimal risk the following should be taken into consideration:

- Mapping of the classroom/ artefacts can cause emotional distress that can include anxiety or causing the participant to evaluate themselves critically. The interviewer will assure the participant that the mapping will be coded and assure anonymity.
- The interviewer will be familiar with the questionnaire in order to insure that the participant does not bear an unfair burden and take more time to complete the questionnaire.
- The questionnaire is 14 pages long. The questionnaire does not need to be completed in a single session. The interviewer will be available to assure that any questions regarding clarity on the questionnaire is provided swiftly in order to not waist the participants time.
- All Covid-19 guidelines will be followed to ensure that any possible risk is eliminated.

Confidentiality and protection of identity

Although the researcher needs to be aware of the identity of participants in the cases where a follow up interview needs to be conducted the identity of the person and the institution where they work will be anonymised in the results. The researcher will adhere strictly to the ethical guidelines

of the NWU to ensure that no school or teacher can be identified. All data will be stored in encrypted files for at least 3 years after this research is concluded and thereafter all data will be destroyed.

Dissemination of findings

After completion of this research all results will be made available to participating sites and teachers via email and/or Google drive.

If you have any further questions or enquiries regarding your participation in this research, please contact the researchers for more information.

DECLARATION BY PROVINCIAL DEPARTMENT OF EDUCATION/PRINCIPAL:

By signing below, I agree to give permission for the research to take place with the identified participants in the study entitled:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

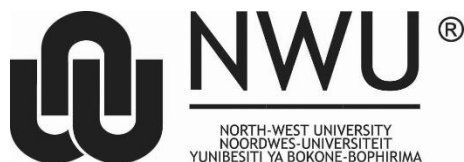
I declare that:

- I have read this information and consent form and understand what is expected of the participants in the research.
- I have had a chance to ask questions to the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and participants will not be pressurised to take part.
- Participants may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- Participants may be asked to leave the research process before it is completed, if the researcher feels it is in their best interests, or if they do not follow the research procedures, as agreed to.

Signed at (place) _____ on (date) ____/____/20____

Signature of Provincial Department of Education/School Principal

ADDENDUM F – GOOD WILL PERMISSION LETTER – SCHOOL GOVERNING BODY



Private Bag X6001, Potchefstroom
South Africa 2520
Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Faculty of Education

(Research entity details: ROE)

Tel: 018 299 1870
Email: Liztie.prinsloo@nwu.ac.za

Date 18/06/2021

GOODWILL PERMISSION: SCHOOL GOVERNING BODY/OTHER RELEVANT BODY

I herewith wish to request your permission for in-service teachers of Grade R-3 to participate in this research, which involves a research study to determine the current state of STEM education with regards to teaching and learning the sciences in Grade R-3. This research aims to answer the current international call for the development of STEM education related research looking at the Grade R-3. This research will provide the African continent with a comprehensive example from South Africa regarding existing and possible practices dealing with STEM as a trans-disciplinary field of research for learners from grade R, 1, 2 and 3. With the knowledge gained from the research the aim will be to make a concrete contribution towards ultimately giving motivations for impacting curriculum policies. Further this study will include contributions towards in service and pre-service training for educators involved in teaching learners between the ages relevant to grade R, 1, 2, and 3. Prior to granting permission, please acquaint yourself with the information below.

The details of the research are as follows:

TITLE OF THE RESEARCH PROJECT:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

ETHICS APPLICATION NUMBER

NWU-01920-20-S2

PROJECT SUPERVISOR: Dr HM van Niekerk

CO-SUPERVISOR: Prof CC Wolhuter

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

MEMBER OF PROJECT TEAM PhD-Student: SE Prinsloo

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

FACULTY OF EDUCATION RESEARCH ETHICS COMMITTEE

Contact person: Ms Erna Greyling, E-mail: Erna.Greyling@nwu.ac.za, Tel. (018) 299 4656

This study has been approved by the Research Ethics Committee of the Faculty of Education of the North-West University and will be conducted according to the ethical guidelines of this committee. Permission was also obtained from the provincial Department of Basic Education/other relevant body.

What is this research about?

The aims of this research is:

- To conceptualize the teaching, learning, and assessment of the natural sciences for Grade R to 3.
- To describe the instruction methods used by teachers for the natural sciences in Grade R-3 with focus on inquiry-based learning, creativity and play.
- To identify the availability, utilization, conceptualization and implementation of resources used in the natural sciences in Grade R-3.
- To propose a framework for policy purposes in order to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development.

Participants

The target population for this study is in-service teachers currently teaching Gr R to 3 in South Africa. The complex nature of the general population in South Africa calls for the inclusion of specific schools where the learners are multi-cultural, ethnic minorities, from different socio-economic status and have different contextual factors present. For the purpose of this study we will then be focusing on teachers in service of Former Model C, farm and rural schools.

What is expected of the participants?

1. Questionnaire completed by the teachers.
2. Allow time for follow-up interview if clarification is needed on questionnaire.
3. Provide anonymised artefacts (mathematics and science lesson plan and classwork).
4. Allow researcher to map out the space (i.e. classroom).

Benefits to the participants

Direct benefits include insight into the current policy and implementation of STEM education in each teachers individual grade. Insight into each teachers own individual approach to STEM education.

Indirect benefits include contributing towards a better understanding of the current state of STEM education in South Africa. Furthermore, contributing a better understanding in order for the researcher to the development of a framework for policy to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development

Risks involved for participants

The study involves the normal educational practices, such as research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods and should therefore cause minimal risks to participants. Even with minimal risk the following should be taken into consideration:

- Mapping of the classroom/ artefacts can cause emotional distress that can include anxiety or causing the participant to evaluate themselves critically. The interviewer will assure the participant that the mapping will be coded and assure anonymity.
- The interviewer will be familiar with the questionnaire in order to insure that the participant does not bear an unfair burden and take more time to complete the questionnaire.
- The questionnaire is 14 pages long. The questionnaire does not need to be completed in a single session. The interviewer will be available to assure that any questions regarding clarity on the questionnaire is provided swiftly in order to not waist the participants time.
- All Covid-19 guidelines will be followed to ensure that any possible risk is eliminated.

Confidentiality and protection of identity

Although the researcher needs to be aware of the identity of participants in the cases where a follow up interview needs to be conducted the identity of the person and the institution where they

work will be anonymised in the results. The researcher will adhere strictly to the ethical guidelines of the NWU to ensure that no school or teacher can be identified. All data will be stored in encrypted files for at least 3 years after this research is concluded and thereafter all data will be destroyed.

Dissemination of findings

After completion of this research all results will be made available to participating sites and teachers via email and/or Google drive.

If you have any further questions or enquiries regarding your participation in this research, please contact the researchers for more information.

DECLARATION BY SGB CHAIRPERSON:

By signing below, I agree to give permission for the research to take place with the identified participants in the study entitled:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

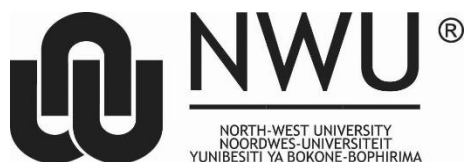
I declare that:

- I have read this information and consent form and understand what is expected of the participants in the research.
- I have had a chance to ask questions to the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and participants will not be pressurised to take part.
- Participants may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- Participants may be asked to leave the research process before it is completed, if the researcher feels it is in their best interests, or if they do not follow the research procedures, as agreed to.

Signed at (place)_____ on (date) ____/____/20____

Signature of SGB Chairperson

ADDENDUM G – INFORMED CONSENT LETTER



Private Bag X6001, Potchefstroom
South Africa 2520
Tel: 018 299-1111/2222
Web: <http://www.nwu.ac.za>

Faculty of Education

(Research entity details: ROE)

Tel: 018 299 1870
Email: Liztie.prinsloo@nwu.ac.za

Date 18/06/2021

PARTICIPANT INFORMATION AND CONSENT FORM

I herewith wish to request your consent to participate in this research, which involves a research study to determine the current state of STEM education with regards to teaching and learning the sciences in Grade R-3. This research aims to answer the current international call for the development of STEM education related research looking at the Grade R-3. This research will provide the African continent with a comprehensive example from South Africa regarding existing and possible practices dealing with STEM as a trans-disciplinary field of research for learners from grade R, 1, 2 and 3. With the knowledge gained from the research the aim will be to make a concrete contribution towards ultimately giving motivations for impacting curriculum policies. Further this study will include contributions towards in service and pre-service training for educators involved in teaching learners between the ages relevant to grade R, 1, 2, and 3. Before you give consent, please acquaint yourself with the information below.

The details of the research are as follows:

TITLE OF THE RESEARCH PROJECT:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

ETHICS APPLICATION NUMBER

NWU-01920-20-S2

PROJECT SUPERVISOR: Dr HM van Niekerk

CO-SUPERVISOR: Prof CC Wolhuter

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

MEMBER OF PROJECT TEAM PhD-Student: SE Prinsloo

ADDRESS: NWU Potchefstroom campus, building B10, room 35

CONTACT NUMBER: 018 299 1870

FACULTY OF EDUCATION RESEARCH ETHICS COMMITTEE

Contact person: Ms Erna Greyling, E-mail: Erna.Greyling@nwu.ac.za, Tel. (018) 299 4656

This study has been approved by the Research Ethics Committee of the Faculty of Education of the North-West University and will be conducted according to the ethical guidelines of this committee. Permission was also asked from the provincial Department of Basic Education as well as the school principal.

What is this research about?

The aims of this research are:

- To conceptualize the teaching, learning, and assessment of the natural sciences for Grade R to 3.
- To describe the instruction methods used by teachers for the natural sciences in Grade R-3 with focus on inquiry-based learning, creativity and play.
- To identify the availability, utilization, conceptualization and implementation of resources used in the natural sciences in Grade R-3.
- To propose a framework for policy purposes in order to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development.

Participants

The target population for this study is in-service teachers currently teaching Gr R to 3 in South Africa. The complex nature of the general population in South Africa calls for the inclusion of specific schools where the learners are multi-cultural, ethnic minorities, from different socio-economic status and have different contextual factors present. For the purpose of this study we will then be focusing on teachers in service of Former Model C, farm and rural schools.

What is expected of you as participant?

1. Questionnaire completed by the teachers.
2. Allow time for follow-up interview if clarification is needed on questionnaire.
3. Provide anonymised artefacts (mathematics and science lesson plan and classwork).
4. Allow researcher to map out the space (i.e. classroom).

Benefits to you as participant

Direct benefits include insight into the current policy and implementation of STEM education in each teachers individual grade. Insight into each teachers own individual approach to STEM education.

Indirect benefits include contributing towards a better understanding of the current state of STEM education in South Africa. Furthermore, contributing a better understanding in order for the researcher to the development of a framework for policy to address the conceptualizations of teachers in Grade R-3 with regards to practices in the classroom, the role of inquiry-based learning, creativity and play in the instruction of mathematics and science, and the use of resources in both in service and pre-service teacher development

Risks involved for participants

The study involves the normal educational practices, such as research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods and should therefore cause minimal risks to participants. Even with minimal risk the following should be taken into consideration:

- Mapping of the classroom/ artefacts can cause emotional distress that can include anxiety or causing the participant to evaluate themselves critically. The interviewer will assure the participant that the mapping will be coded and assure anonymity.
- The interviewer will be familiar with the questionnaire in order to insure that the participant does not bear an unfair burden and take more time to complete the questionnaire.
- The questionnaire is 14 pages long. The questionnaire does not need to be completed in a single session. The interviewer will be available to assure that any questions regarding clarity on the questionnaire is provided swiftly in order to not waist the participants time.
- All Covid-19 guidelines will be followed to ensure that any possible risk is eliminated.

Confidentiality and protection of identity

Although the researcher needs to be aware of the identity of participants in the cases where a follow up interview needs to be conducted the identity of the person and the institution where they work will be anonymised in the results. The researcher will adhere strictly to the ethical guidelines

of the NWU to ensure that no school or teacher can be identified. All data will be stored in encrypted files for at least 3 years after this research is concluded and thereafter all data will be destroyed.

Dissemination of findings

After completion of this research all results will be made available to participating sites and teachers via email and/or Google drive.

If you have any further questions or enquiries regarding your participation in this research, please contact the researchers for more information.

Yours sincerely
(SE Prinsloo)

DECLARATION BY PARTICIPANT:

By signing below, I agree to take part in a research study entitled:

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3.

I declare that:

- I have read this information and consent form and understand what is expected of me in the research.
- I have had a chance to ask questions to the researcher and all my questions have been adequately answered.
- I understand that taking part in this study is voluntary and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be penalised or prejudiced in any way.
- I may be asked to leave the research process before it has finished, if the researcher feels it is in my best interests, or if I do not follow the research procedures, as agreed to.

Signed at (place) _____ on (date) ____/____/20____

Signature of participant

Researcher

ADDENDUM H – MAPS OF THE SPACE

Observations of 35 cases was recorded with a map of each space indicating the classroom layout together with listing resources. The result from the observations is listed in the table below.

	Farm school	Township school	Model C school
Cases (Classrooms)			
Classical classroom layout	8 out of 11	12 out of 19	4 out of 5
Grouped classroom layout	3	8	1
Stationary	4	8	5
Story books in class	7	8	5
Educational toys	1	7	4
Carpets	4	7	5
Sites (Schools)			
Outside play area	1 out of 3	2 out of 4	1 of 1
Computer centre	3	4	1

Table: Observation summary

Below are two prototypes of how the space was mapped:

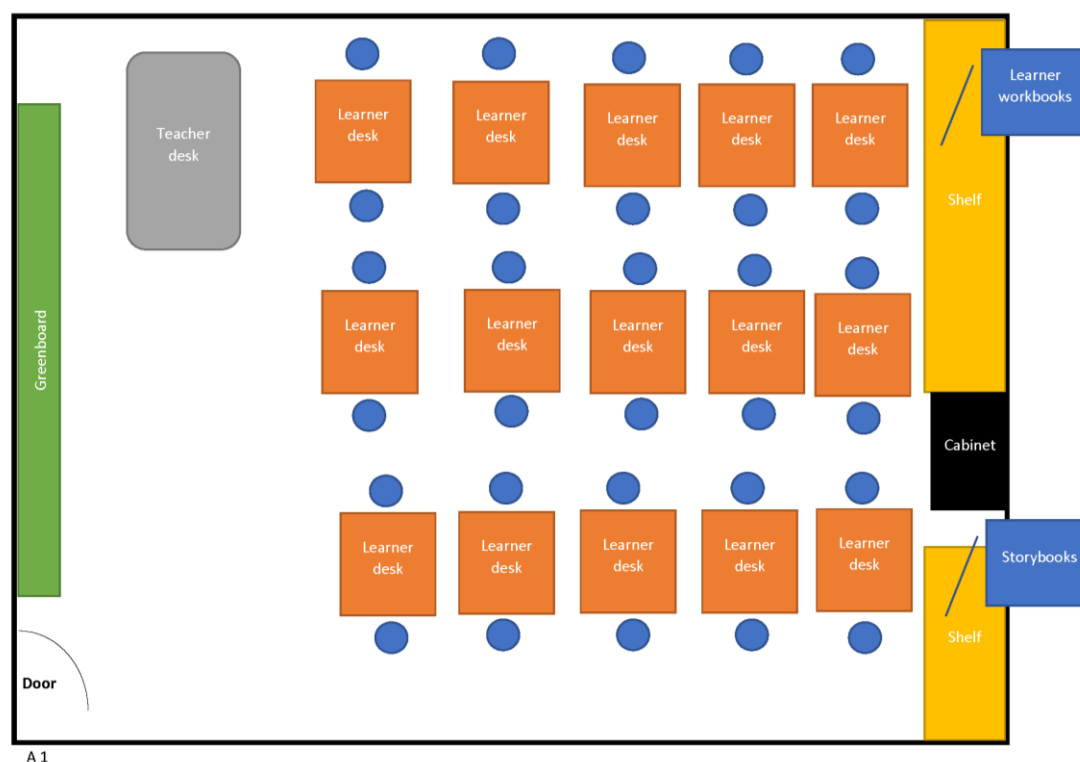


Figure: Classroom map prototype 1

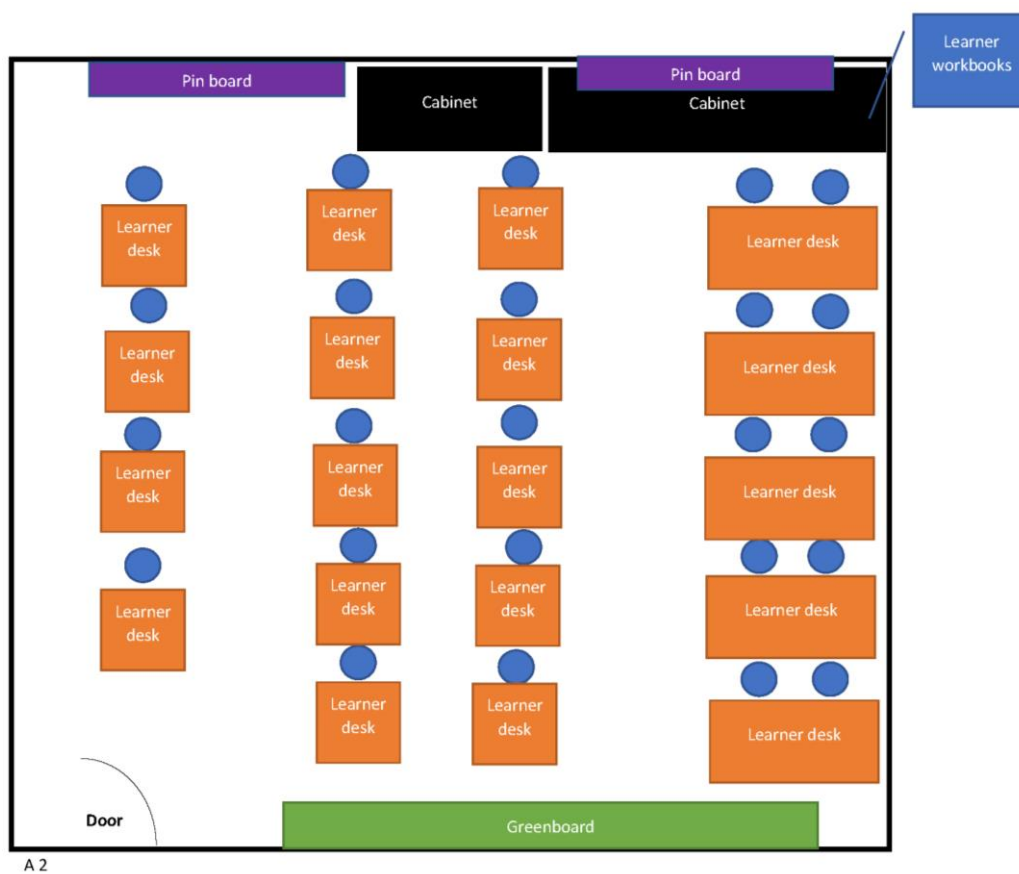


Figure: Classroom map prototype 2

ADDENDUM I – LANGUAGE EDITOR CERTIFICATE

PROOF OF EDITING

Dr. L. Hoffman, APed (SATI), APRed (SAVI)

Klerksdorp

BA, BA(Hons), MA, DLitt et Phil, Certificate (English Grammar for Editors)

Accredited Professional Text Editor – English and Afrikaans (South African Translators' Institute)

Member of South African Translators' Institute – No. 1003545

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DECLARATION

To whom it may concern

I hereby confirm that I have edited and proofread the following thesis, including the bibliography.

Title of thesis

Comparing different types of schools in South Africa regarding STEM guidance for teaching and learning in Grades R, 1, 2 & 3

Student

SE Prinsloo



Lariza Hoffman

Klerksdorp

31 July 2022

ADDENDUM J – TURNITIN REPORT SUMMARY

20356404:SE_Prinsloo_PhD.pdf
by LIZTIE PRINSLOO

Submission date: 05-Aug-2022 09:01PM (UTC+0200)

Submission ID: 1879223193

File name: gnments_e8626072-ebfe-4fae-bfcf-c55962a9104c_SE_Prinsloo_PhD.pdf (16.48M)

Word count: 89409

Character count: 498300